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Valid estimation of the optic disc: the case against using cup/disc ratio

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Received: 2011-03-28 Accepted: 2011-07-12

Abstract

• Glaucoma is a kind of progressive disease characterized by distinctive defects of optic disc cupping and visual field loss associated with or without intraocular pressure elevated. The cup/disc ratio is the standard way to describe the optic disc in the past 40 years. But the fact is that there were cases in which glaucomatous visual field loss was associated with a small cup , and cases in which visual field loss was not present even though the cup was large. The cup/disc ratio is less valid and reproducible than new methods. The Disc Damage Likelihood Scale (DDLS), which is based on the appearance of the neuroretinal rim of the optic disc, corrected for the disc diameter, may be a better system to evaluate the optic disc.

• KEYWORDS: glaucoma; optic disc; cup/disc ratio; DDLS
DOI: 10. 3969/j. issn. 1672-5123. 2011. 08. 002

Wei H, Zangalli C, Spaeth GL. Valid estimation of the optic disc: the case against using cup/disc ratio. *Guoji Yanke Zazhi(Int J Ophthalmol)* 2011; 11(8): 1314-1317

INTRODUCTION

Glaucoma is a process in which the tissues of optic nerve become progressively damaged, partially related to intraocular pressure. As the definition of glaucoma has evolved over the last 2000 years, the importance of the "characteristic appearance of the optic nerve" in glaucoma has increased. Many recent definitions stress that glaucoma "is a characteristic optic neuropathy"[1, 2]. Glaucoma is one of many optic neuropathies; thus, the word "characteristic" is the key in understanding what glaucoma is and how it can be recognized. Non arteritic anterior ischemic optic neuropathy (NAION)[3], anterior ischemic optic neuropathy (AION)[4], hereditary optic neuropathies such as Leber's hereditary optic neuropathy[5], compressive lesions and methanol toxicity[6] are all conditions in which cupping of the disc can occur.

CASE REPORT

The cup/disc ratio After the ophthalmoscope was invented in the middle of the 19th century, visualization of the optic nerve became possible, and the association between a hard eye and a "cupped" optic nerve became apparent. Less than 20 years later, Jaeger[7] published exquisitely accurate pictures of "cupping" of the optic nerve, even indicating the reversibility of the process. "Cupping" of the optic nerve as a hallmark of glaucoma was commented by Elliot[8]: "Cupping of the optic disc is, next to the increase in ocular tension, the best-known sign of glaucoma".

Science requires measurement, the more accurate the measurement the better. A major advance in understanding glaucoma occurred in 1969 when Armaly[9] described the cup/disc (C/D) ratio system. Other authors had developed clinically-useful systems of characterizing the optic nerve[10]. These did not become popular, perhaps because they were fairly complex and did not provide the easy quantification of the C/D ratio method. Armaly's method was simplicity itself: estimate in tenths the proportion of the width of the cup of the disc in comparison to the width of the entire disc. There was a relationship between the C/D ratio and the amount of visual field loss[11]. The distribution of C/D ratio was described, and it was concluded that C/D ratio greater than 0. 3 were characteristic of "glaucoma"[12]. Virtually, every paper published on glaucoma since 1970 used the C/D system to describe the optic nerve. The importance of C/D ratio in defining, characterizing and following glaucoma became so dominant, that some studies, such as the Collaborative Initial Glaucoma Treatment system allowed the C/D ratio to be used as a criterion for enrollment[13].

For over 100 years it has been noted that the relationship between cupping and glaucomatous visual field loss is complex. However, there is some relationship between the size of the cup and the presence or absence of glaucoma; C/D is related to glaucoma. (As we will argue from here on, the problem is that the relationship is not as close as believed,

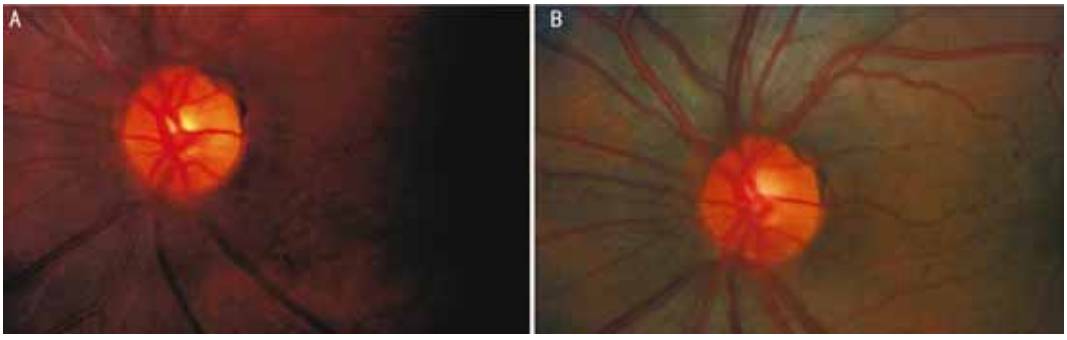

Figure 1 Changes of the optic disc of the patients with intraocular pressure A: An optic disc of the patient with intraocular pressures ranging around 40mmHg; B: Progressive cupping of the optic nerve as seen in Figure 1B was noted 1 year after 1A.

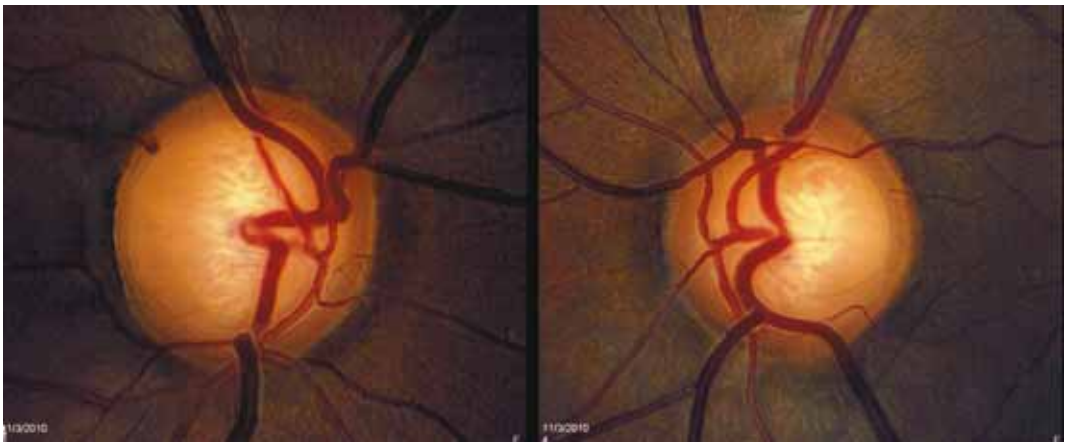

Figure 2 The optic discs of a 50-year-old man followed up for over 20 years without the development of any visual field loss or change in appearance of the optic nerves. Intraocular pressures have been consistently between 14 and 16mmHg in each eye. The patient definitely does not have glaucoma.

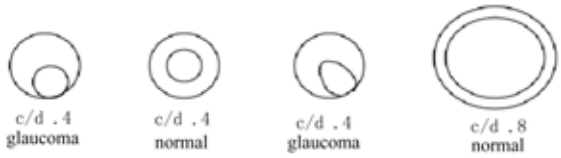

Figure 3 Three discs of average size and a large disc. The cup/disc ratio of the three smaller discs are about the same. But the second disc is probably healthy and the others certainly abnormal. The C/D ratio does not tell the well from the sick. The large disc has the biggest cup. It also has the greatest rim area and of all the four discs is the most likely not to be glaucomatous.

and that there are now better systems available.) The fact, then, is the relationship between C/D and glaucoma combined with the ease of estimating the C/D ratio, resulted in the C/D method becoming the standard way to describe the optic disc, despite the fact that there were , on one hand, cases in which glaucomatous visual field loss was associated with a small cup (Figure 1), and on the other hand, cases in which visual field loss was not present even though the cup was large (Figure 2).

There are different ways in which the optic nerve can become damaged in glaucoma. It is not merely cup size that is the characteristic aspect of glaucoma; but rather, the pattern of the cup is more important. Kirsch and Anderson, and others, described vertical elongation of the cup as typically occurring in glaucoma[14, 15]. The presence of a notched rim became popular as a method of distinguishing glaucomatous cups from cups that were not glaucomatous. For example, the disc graphically illustrated in Figure 3A is highly likely to be a disc of a patient with glaucoma, whereas that in Figure 3B, in which the C/D ratio is the same size, is not likely to be seen in patients with glaucoma. The position of the cup, then, is more important than the size of the cup in determining whether a disc is glaucomatous or not.

A breakthrough came with the publication of papers noting that the size of the optic cup was related to the size of the optic disc[16]. By and large, big discs have big cups and small discs have small cups. This observation explained why many patients such as that illustrated in Figure 2 do not have either glaucoma, or visual field loss. They have discs with large cups, but the discs are healthy.

The disc shown in Figure 3B has a much smaller cup than that in Figure 3D, but the rim area in 3D is actually larger than that in 3B. 3D is less likely to be a glaucomatous disc than 3B. Because the cup/disc ratio system does not take into account

	Narrowest width of rim (rim/disc ratio)					Examples	
DDLS Stage	For Small Disc <1.50 mm	For Average Size Disc 1.50-2.00 mm	For Large Disc >2.00 mm	DDLS Stage	1.25 mm optic nerve	1.75 mm optic nerve	2.25 mm optic nerve
1	.5 or more	.4 or more	.3 or more	0a			
2	.4 to .49	.3 to .39	.2 to .29	0b			
3	.3 to .39	.2 to .29	.1 to .19	1			
4	.2 to .29	.1 to .19	less than .1	2			
5	.1 to .19	less than .1	0 for less than 45°	3			
6	less than .1	0 for less than 45°	0 for 46° to 90°	4			
7	0 for less than 45°	0 for 46° to 90°	0 for 91° to 180°	5			
8	0 for 46° to 90°	0 for 91° to 180°	0 for 181° to 270°	6			
9	0 for 91° to 180°	0 for 181° to 270°	0 for more than 270°	7a			
10	0 for more than 180°	0 for more than 270°		7b			

Figure 4　**The Disc Damage Likelihood Scale.**

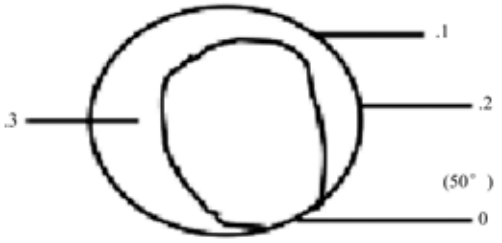

Figure 5　**A disc with rim/disc ratio shown.**

the position of the cup and the size of the disc, it is not a highly reliable method of distinguishing normal from abnormal.

The Disc Damage Likelihood Scale (DDLS)　In 2002, a new method of evaluating the optic nerve head, the Disc Damage Likelihood Scale (DDLS) was described (Figure 4)[17,18]. This system relies on two characteristics of the disc: the width of the neuro-retinal rim and the size of the optic disc. The width of the rim is estimated in terms of a rim/disc ratio (R/D). The widest possible R/D would be 0.5, the narrowest 0.0 (Figure 5). Loss of rim tissue can progress to the extent that there is no apparent rim tissue remaining. This loss typically starts in one area and extends circumferentially. Grading of the amount of damage is estimated in terms of R/D ratio, or the amount of circumferential loss of rim in degrees corrected for disc size (Figure 4). Where there is virtually no cup (R/D > 4) the DDLS is 1 in an average sized disc, and 2 in a small disc. When the R/D is less than 1 R/D the DDLS is 5 in an average disc, 4 in a large disc and 6 in a small disc. Where there is no rim for 1-45° the disc is a DDLS 6, 46-90° a DDLS 7 , 91-180° a DDLS 8, 181-270° a DDLS 9 and more than 270°, a DDLS 10. Because the R/D will be affected by disc size, size must also be determined. The rule is to add one DDLS unit for a small disc and subtract one unit for a large disc.

SUMMARY

DDLS is mentioned here because it is easily learned and able to be utilized immediately without any specialized equipment. It is not mentioned in order to suggest that it is superior to other present techniques that do not use the cup/disc ratio system. In fact, the DDLS has the great disadvantage that it is a subjective method and requires a skilled observer, usually a specially-trained physician. There are other ways to measure rim width, analyze the appearance of the optic disc and measure disc size. For example, the size of the optic disc can be evaluated by using a high-plus lens at the slit lamp[19], using an ophthalmoscope[20], with automated image equipment such as the Heidelberg Retinal Tomography[21], or with photographs that take into account the optical properties of the camera and of the eye[22]. All of these are highly satisfactory

methods. This report is not a promotion for the DDLS. It is a plea to stop using an outdated system (cup/disc ratios) that does not work as well as other available systems. It is disrespectful to patients and to the professors to continue to use an outdated method when newer, equally user-friendly techniques are available and are no more expensive. The point we make here, then, is that the C/D system, while a useful method when other systems were not available, is less valid than newer methods, and is neither easier to use nor reproducible.

REFERENCES

1 Shields MB, Spaeth GL. The Glaucomatous Process and the Evolving Definition of Glaucoma. *J Glaucoma* 2011 Jun 8;[Epub ahead of print]

2 Foster PJ, Buhrmann R, Quigley HA, Johnson GJ. The definition and classification of glaucoma in prevalence surveys. *Br J Ophthalmol* 2002;86(2):238-242

3 Danesh-Meyer HV, Savino PJ, Sergott RC. The prevalence of cupping in end-stage arteritic and nonarteritic anterior ischemic optic neuropathy. *Ophthalmology* 2001;108(3):593-598

4 Choudhari NS, George R, Kankaria V, Sunil GT. Anterior ischemic optic neuropathy precipitated by acute primary angle closure. *Indian J Ophthalmol* 2011;58(5):437-440

5 O'Neill EC, Danesh-Meyer HV, Kong GX, Hewitt AW, Coote MA, Mackey DA, Crowston JG. Optic disc evaluation in optic neuropathies the optic disc assessment project. *Ophthalmology* 2011;118(5):964-970

6 Piette SD, Sergott RC. Pathological optic-disc cupping. *Curr Opin Ophthalmol* 2006;17(1):1-6

7 Jaeger EV. Ophthalmoskopischer Hand-atlas: Wien, Verlag der k. k. *Hof-und Staatsdruckerei* 1869

8 Elliot RH. A Treatise on Glaucoma: Henry Frowde& Hodder and Stroughton Ltd, 1922

9 Armaly MF, Sayegh RE. The cup-disc ratio. The findings of tonometry and tonography in the normal eye. *Arch Ophthalmol* 1969;82(2):191-196

10 Hoffmann EM, Zangwill LM, Crowston JG, Weinreb RN. Optic disk size and glaucoma. *Surv Ophthalmol* 2007;52(1):32-49

11 Durmus M, Karadag R, Erdurmus M, Totan Y, Feyzi Hepsen I. Assessment of cup-to-disc ratio with slit-lamp funduscopy, Heidelberg Retina Tomography Ⅱ, and stereoscopic photos. *Eur J Ophthalmol* 2009;19(1):55-60

12 Oliveira AC, Oliveira FC, Villa Albers MB, Cohen R, Kasahara N. Clinical correlation between structural and functional assessment in glaucoma: Armaly cup to disk ratio and Brusini glaucoma staging system. *Arq Bras Oftalmol* 2008;71(2):242-245

13 Musch DC, Lichter PR, Guire KE, Standardi CL. The Collaborative Initial Glaucoma Treatment Study: study design, methods, and baseline characteristics of enrolled patients. *Ophthalmology* 1999;106(4):653-662

14 Chihara E, Chihara K. Covariation of optic disc measurements and ocular parameters in the healthy eye. *Graefes Arch Clin Exp Ophthalmol* 1994;232(5):265-271

15 Kirsch RE, Anderson DR. Clinical recognition of glaucomatous cupping. *Am J Ophthalmol* 1973;75(3):442-454

16 Oddone F, Centofanti M, Tanga L, Parravano M, Michelessi M, Schiavone M, Villani CM, Fogagnolo P, Manni G. Influence of Disc Size on Optic Nerve Head versus Retinal Nerve Fiber Layer Assessment for Diagnosing Glaucoma. *Ophthalmology* 2011;118(7):1340-1347

17 Spaeth GL, Henderer J, Liu C, Kesen M, Altangerel U, Bayer A, Katz LJ, Myers J, Rhee D, Steinmann W. The disc damage likelihood scale: reproducibility of a new method of estimating the amount of optic nerve damage caused by glaucoma. *Trans Am Ophthalmol Soc* 2002;100:181-186

18 Henderer JD, Liu C, Kesen M, Altangerel U, Bayer A, Steinmann WC, Spaeth GL. Reliability of the disk damage likelihood scale. *Am J Ophthalmol* 2003;135(1):44-48

19 Ruben S. Estimation of optic disc size using indirect biomicroscopy. *Br J Ophthalmol* 1994;78(5):363-364

20 Gross PG, Drance SM. Comparison of a simple ophthalmoscopic and planimetric measurement of glaucomatous neuroretinal rim areas. *J Glaucoma* 1995;4(5):314-316

21 Hornova J, Kuntz Navarro JB, Prasad A, Freitas DG, Nunes CM. Correlation of Disc Damage Likelihood Scale, visual field, and Heidelberg Retina Tomograph Ⅱ in patients with glaucoma. *Eur J Ophthalmol* 2008;18(5):739-747

22 Medeiros FA, Zangwill LM, Bowd C, Vessani RM, Susanna R, Jr., Weinreb RN. Evaluation of retinal nerve fiber layer, optic nerve head, and macular thickness measurements for glaucoma detection using optical coherence tomography. *Am J Ophthalmol* 2005;139(1):44-55

视盘的有效评估:与杯盘比的对比

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摘要

青光眼是一种以进行性视盘变化和视野损失为特征的眼压相关性疾病。杯盘比在过去40a来都是评价视盘青光眼性改变的标准方法。然而我们却发现是一些小视盘的患者有典型青光眼性视野损失,而一些大视盘的患者却没有视野损失。杯盘比的检查效力和可重复性都低于一些新的检查方法。视盘损伤可能度分级(DDLS)是一种衡量视盘盘沿面积、并且校正了视盘大小等影响因素的新型视盘评价方法。DDLS也许是评价青光眼视盘的更为优化的方法。

关键词:青光眼;视神经盘;杯盘比;视乳头损伤分期法