What optic disc parameters are most accurately assessed using the direct ophthalmoscope?

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CLINICAL STUDY

Abstract

Purpose **It has been suggested that over-reliance on the cup-to-disc ratio is a major factor in the misinterpretation of the optic disc. In spite of this optometrist assessment of the optic disc tends to be restricted to measurement of the cup-to-disc ratio and cup depth only. Would interpretation of the disc improve if optometrists were to evaluate other parameters? The aim of this study was to evaluate the accuracy of optometrist assessment of nine parameters of the optic nerve head using direct ophthalmoscopy.**

Methods **Eight optometrists evaluated nine parameters of the optic nerve head (vertical disc diameter, vertical cup-to-disc ratio, neuroretinal rim configuration, cup shape, neuroretinal rim colour, vessel path, presence/absence of haemorrhage, extent and location of peripapillary atrophy and classification of health status of the disc) in 50 eyes of 50 patients using direct ophthalmoscopy. Intensive training in optic nerve head assessment was given prior to assessing the patients. Criteria for evaluation were discussed. The 'gold standard' reference was the classification of the parameters by a consultant ophthalmologist with a special interest in glaucoma.**

Results **Interobserver agreement for vertical cup-to-disc ratio was almost perfect (mean weighted kappa 0.84). Agreement for neuroretinal rim configuration, cup shape, haemorrhage and final classification of the disc was good (mean kappa 0.62–0.67). There was moderate agreement for vessel configuration (mean kappa 0.53). For assessment of peripapillary atrophy, disc size and neuroretinal rim colour, agreement was fair (mean kappa 0.22–0.34).**

Conclusions **Accuracy of assessment was greatest for vertical cup-to-disc ratio, neuroretinal rim configuration and cup shape. Improved agreement has been demonstrated for the final classification of the disc compared with previous reports. The combination of training and assessment of additional disc parameters appears to improve interpretation of the optic nerve head by optometrists.**

Key words Direct ophthalmoscopy, Disc parameters, Glaucoma, Optometrist

Optometrists are responsible for over 90% of referrals for suspected glaucoma to hospital ophthalmology clinics.[1] Studies have shown the positive predictive value (PPV) of referrals to vary between 17% and 72%.[2] Recently there has been concern about a reduction in the PPV of optometrist referrals. It has been suggested that this may be the result of increased use of visual field testing by optometrists and/or a greater tendency to refer on disc appearance in an attempt to identify more cases of normal tension glaucoma.[3]

Our own analysis of referrals for suspected glaucoma has revealed that optometrist assessment of the optic nerve head tends to be restricted to measurement of the cup-to-disc ratio and depth of cupping using direct ophthalmoscopy. It has been suggested that over-reliance on the cup-to-disc ratio is a major factor in the misinterpretation of the optic disc because of its dependence on disc size.[4] The diversity in normal disc morphology makes interpretation difficult.[5] Would this interpretation improve if optometrists were to evaluate other parameters of the disc in addition to the cup-to-disc ratio and cup depth?

This study investigated the accuracy of optometric reporting of nine separate parameters of the optic disc following training in disc assessment. Assessments were made using a direct ophthalmoscope through an undilated pupil to represent the most common method used in high street practices. Previous studies have been limited by the use of photographs.

Materials and methods

Eight optometrists participated in the study, all of whom work in high street optometric practice. Six of the optometrists also work part-time in the hospital eye service. Their hospital work was not connected with the glaucoma service.

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Fifty volunteers were recruited via the glaucoma clinics at Moorfields Eye Hospital. Some of the volunteers were existing patients and some were friends or relatives of the patients.

The optometrists attended 2 hours of lectures on assessment of the optic nerve head. The lecture programme paid particular attention to the assessment of nine parameters: vertical disc diameter, vertical cup-to-disc ratio, neuroretinal rim configuration, cup shape, neuroretinal rim colour, vessel path, presence/absence of haemorrhage, extent and location of peripapillary atrophy and classification of health status of the disc. The Moorfields Ethics Committee granted ethics approval.

The optometrists assessed one eye only (undilated) of each of 50 patients. Using a structured form, they were asked to grade each of the parameters as being within or outside normal limits and to give a final opinion on the health of the optic disc, i.e. normal or glaucomatous. Criteria for normal and abnormal appearances were discussed in the lecture programme. When assessing the vertical disc diameter the optometrists were asked to grade the diameter as small, medium or large. This was assessed by comparing the size of the smallest round spot of light (1.5 mm using a Welch Allyn ophthalmoscope,[6] 0.8 mm using a Keeler Specialist Ophthalmoscope) with the vertical diameter of the disc.

Prior to being assessed by the optometrists each patient was examined by a consultant ophthalmologist (I.M.) who has a special interest in glaucoma. Patients were examined through undilated pupils since this is the situation in most high street practices. The ophthalmologist examined both eyes of each patient using slit-lamp biomicroscopy and selected the eye to be examined by the optometrist. A wide range of normal and glaucomatous optic disc appearances were selected, ensuring a range of signs for each parameter. This binocular assessment of the disc, although of necessity through undilated pupils, represented the 'gold standard'. The ophthalmologist assessed the vertical disc diameter by projecting the slit beam over the disc and adjusting its height to coincide with the vertical disc height. The measurement was read off the slit-lamp scale. The disc margin was taken as the inner margin of the scleral ring. Assessment of the ophthalmologist's reproducibility for this measurement showed a mean difference between repeat readings of –0.01, standard deviation 0.07 mm.

Results

Data were recorded from 50 eyes of 50 patients. Twenty-three eyes were glaucomatous, of which 14 had advanced, 4 moderate and 5 early glaucomatous optic nerve head changes. A disc was categorised as having advanced changes if complete tissue loss to the disc margin for more than 3 clock-hours was present. Early changes were defined as an isolated notch or abnormal thinning of the neuroretinal rim for less than 4 clock-hours. The criteria for moderate glaucomatous damage fell between the above for early and advanced changes. The agreement between the ophthalmologist and each optometrist (interobserver agreement) was determined for all parameters and for the final classification of the disc, using the kappa statistic or weighted kappa statistic. A value of 0.00–0.20 was considered poor agreement, 0.21–0.40 fair agreement, 0.41–0.60 moderate agreement, 0.61–0.80 good agreement and 0.81–1.00 very good agreement.[7] The results are shown in Table 1.

Agreement for vertical cup-to-disc ratio was very good. Agreement for neuroretinal rim configuration, cup shape and haemorrhage (with the exception of optometrist C) was good. There was moderate agreement when vessel configuration was assessed. For assessment of peripapillary atrophy, disc size and neuroretinal rim colour the agreement was fair. There was good agreement for the final classification of the disc as glaucomatous or normal.

The agreement between the optometrists and the ophthalmologist for the vertical cup-to-disc ratio was also assessed by measurement of inter-test differences. Fig. 1 illustrates the Altman Bland plot. It can be seen that the optometrists overestimate cup-to-disc ratios with a mean value less than 0.5 and underestimate cup-to-disc ratios with a mean value greater than 0.6. Sixty-five per cent (range 49–75%) of measurements of vertical cup-to-disc ratio by the optometrists were within ± 0.10 disc diameters of the ophthalmologist's measurements (0.1 difference or less); 87% (range 74–93%) of measurements were within ± 0.2 (0.2 difference or less).

Table 1. *Agreement (kappa) between ophthalmologist and optometrists (B–I) for each disc parameter*

	Optometrist								
Parameter	B	C	D	E	F	G	H	I	Mean 95% CI
Vertical disc diameter[a]	0.50	0.19	0.30	0.37	0.27	0.23	0.38	0.46	0.34 (0.26–0.42)
Vertical cup-to-disc ratio[a]	0.78	0.87	0.85	0.88	0.86	0.85	0.84	0.76	0.84 (0.81–0.87)
Neuroretinal configuration	0.75	0.82	0.75	0.62	0.45	0.54	0.80	0.62	0.67 (0.58–0.76)
Cup shape	0.76	0.65	0.76	0.84	0.51	0.62	0.61	0.55	0.66 (0.58–0.74)
Neuroretinal rim colour	0.44	0.23	0.36	0.25	0.25	0.35	0.43	0.21	0.32 (0.25–0.38)
Vessel configuration	0.65	0.55	0.63	0.60	0.58	0.46	0.60	0.13	0.53 (0.40–0.65)
Haemorrhage	0.85	0.00	0.89	0.40	0.80	0.80	0.80	0.80	0.67 (0.45–0.89)
Peripapillary atrophy	0.16	0.40	0.21	0.31	0.26	0.07	0.23	0.08	0.22 (0.14–0.29)
Health status of optic nerve head	0.84	0.66	0.60	0.64	0.48	0.45	0.68	0.60	0.62 (0.53–0.70)

[a]Weighted kappa statistic is given for vertical disc diameter and vertical cup-to-disc ratio.

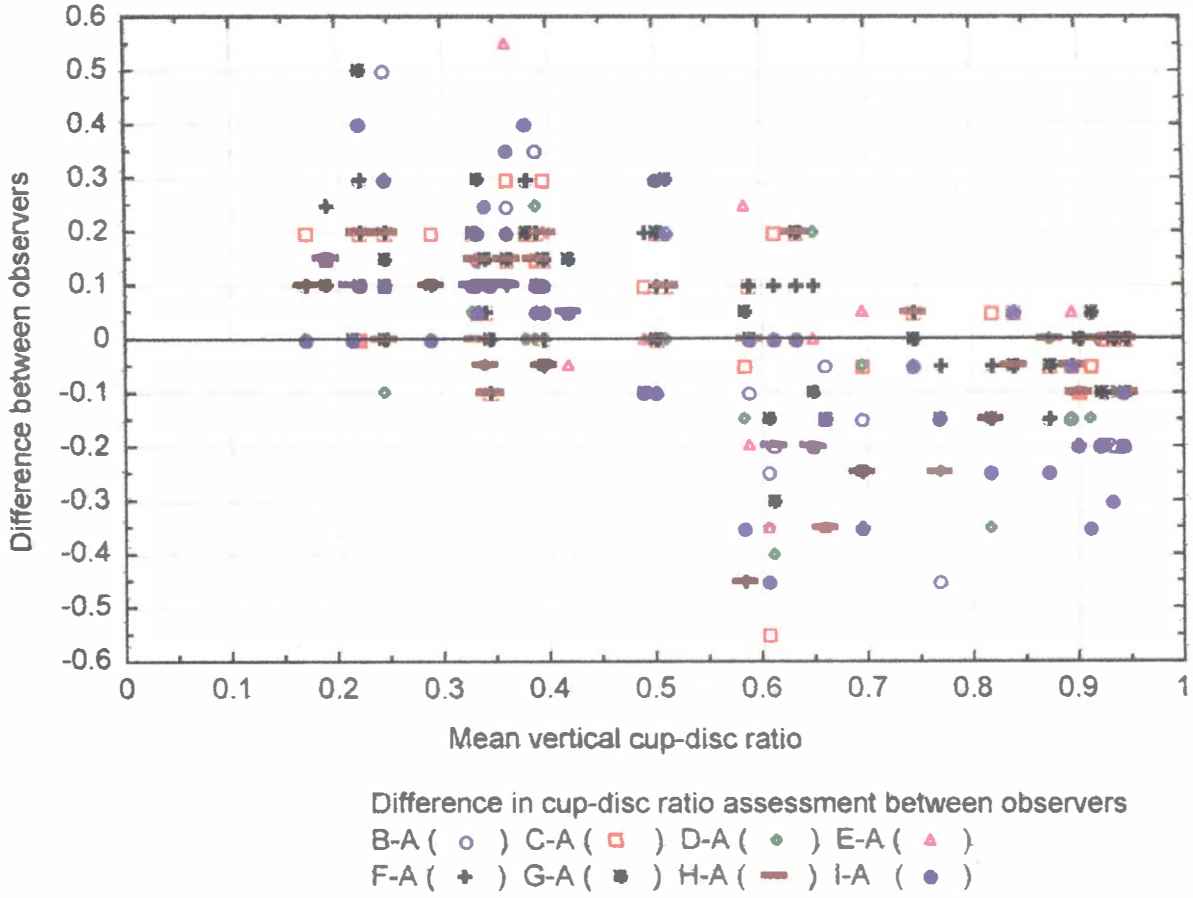

Fig. 1. *Altman Bland plot (inter-test differences) to demonstrate the agreement between the ophthalmologist and optometrists for the vertical cup-to-cup disc ratio.*

The sensitivity and specificity for final classification of the disc were determined for each optometrist. The results are shown in Table 2.

Discussion

The results of this study have shown good agreement between the ophthalmologist and optometrists for over half the parameters assessed. Agreement for vertical cup-to-disc ratio was very good. For neuroretinal rim configuration and cup shape agreement was good. Six of the eight optometrists accurately identified haemorrhage. However, in the population we investigated there were only three discs with haemorrhages. This may explain the spurious result for optometrist C and our confidence in the results for agreement with respect to this parameter has to be guarded. The method used to assess disc size was a new concept to the optometrists. This may explain why agreement for this parameter was only fair.

There are a number of possible explanations for optometrists having poorer agreement with the ophthalmologist for the remaining four parameters. These include a difference in the equipment used, a difference in the criteria adopted for assessment, difficulty interpreting the disc parameter because of poorly defined features and a difference in level of clinical experience. Assessment of inter-optometrist agreement may help to identify the most plausible explanation. We found inter-optometrist agreement to be good for neuroretinal rim colour (kappa 0.49–0.64). This suggests that the difference in equipment used may have contributed to the disagreements with the ophthalmologist. There was poor inter-optometrist agreement for assessment of peripapillary atrophy (kappa 0.12–0.51) and vertical disc size (kappa 0.084–0.63). This suggests that different criteria were used by each individual, interpretative difficulties existed for the parameters or a lack of clinical experience

Table 2. *Sensitivity and specificity of each optometrist's classification of the health status of the optic disc*

	Optometrist								
	B	C	D	E	F	G	H	I	Mean 95% CI
Sensitivity	91	96	87	96	86	81	87	96	90 (86–94)
Specificity	93	72	74	67	63	65	82	67	73 (66–80)

was to blame. A study of intra-observer variation would help resolve which of these was the explanation for the poor agreement.

In previous studies, researchers have generally investigated the agreement between ophthalmologists for measurement of vertical cup-disc ratio using optic disc photographs. Variable results have been reported with weighted kappa values ranging from 0.57 to 0.84.[8–11] In a study by Abrams *et al.*[12] the agreement between six ophthalmologists using stereoscopic disc photographs was significantly higher (0.68) than between six optometrists using the same photographs (0.56). Our results show very good agreement between the ophthalmologist and the optometrists (0.84). Sixty-five per cent of measurements were within and including 0.1 (87% within and including 0.2) disc diameters of the ophthalmologist's despite monocular disc assessment. Varma *et al.*[11] reported a similar finding: 68% of measurements were within and including 0.1 for monoscopic disc assessment. However, overall Varma *et al.* reported less agreement (0.57), which improved for stereoscopic assessment of photographs (0.67). The high level of agreement in our study may be explained by the training period immediately prior to the trial. In addition the discs were assessed using familiar clinical methods rather than viewing photographs. However, our results may have been limited by monoscopic viewing and by the fact that the ophthalmologist used different equipment to the optometrists.

In this study there was a tendency for the optometrists to overestimate vertical cup-to-disc ratios at the lower end of the range and underestimate ratios greater than 0.6. Monoscopic viewing may explain these findings. In both normal and glaucomatous discs the area of pallor is smaller than the actual area of the cup. Under monoscopic assessment there is a tendency to use the area of pallor to demarcate the cup, resulting in an underestimation of its size.

Agreement between ophthalmologists for a diagnosis of glaucoma was the same for both monoscopic and stereoscopic viewing in Varma *et al.*'s study: 0.50 in each group. Abrams *et al.* reported poorer agreement for glaucomatous damage, with no significant difference amongst ophthalmologists (0.47) and optometrists (0.40). Our result of 0.64 compares very favourably with these other results. Both Abrams *et al.*[12] and Montgomery and Craig[4] noted a tendency for observers to over-rely on the cup-to-disc ratio as an indicator of glaucomatous damage. It was suggested that the significance of the disc size was overlooked and that this led to errors in disc interpretation. Large optic discs have large physiological cups and the significance of the cup-to-disc ratio depends on the disc size. In this study disc size was one of the parameters assessed. Although agreement between the optometrists and the ophthalmologist for this parameter was only fair, its inclusion in the overall evaluation of the disc may explain the improvement in accuracy for the final classification of the optic nerve. Moreover, in our study the optometrists evaluated a total of eight parameters before making a decision on the health status of the disc.

Our results show very high sensitivity (90%) and specificity (73%) for identifying glaucomatous damage. Abrams *et al.*[12] reported a poorer specificity for ophthalmologists (60%) and optometrists (53%). In their study the sensitivity amongst ophthalmologists (78%) was good and higher than amongst optometrists (56%). In our study six of the eight optometrists worked part-time in the hospital eye service, which may account in part for the difference in findings and limit the generalisability of our results. The discrepancy between the studies may be further explained by a difference in the interpretative difficulty of the optic discs assessed. Early glaucomatous disc changes will be more difficult to differentiate than advanced pathology. In this study we have reported the severity of glaucoma in our patients, although this may be limited because only one ophthalmologist was responsible for classification of the disc appearances. Details regarding the range of appearances would have further strengthened this study; however, the ophthalmologist attempted to ensure as broad a range as possible was selected. As already mentioned, the structured approach to evaluating the appearance of each disc, which included the assessment of eight individual parameters prior to the overall classification, may also explain the high levels of accuracy achieved.

Our agreement for assessment of neuroretinal rim colour (kappa 0.32) is worse than past work showing good agreement between ophthalmic nurses and ophthalmologists for optic disc colour (kappa 0.73).[13] As outlined above, we believe this could be an equipment effect, especially as batteries in the direct ophthalmoscopes were failing towards the end of the day.

In the current study the agreement between the optometrists and the ophthalmologist for assessment of peripapillary atrophy was poor. This is in contrast to Tuulonen *et al.*'s findings,[14] who reported high interobserver correlations with no significant difference in measurements between the two observers. Enlarged photographs were viewed stereoscopically and the peripapillary areas were measured using planimetric techniques.[14] The difference in results may be explained by the different methods of assessment and the different criteria for evaluation. Less clinical experience in assessment of peripapillary atrophy may have contributed to the difference. Irregular and poorly defined borders make assessment of peripapillary atrophy difficult.

To our knowledge, this is the first time the accuracy of evaluation of neuroretinal rim configuration, cup shape and vessel path has been investigated. The level of interobserver agreement reported suggests these parameters are clinically useful measures for evaluating the optic nerve head.

This study did not assess the repeatability of evaluation. However, previous studies have demonstrated high reproducibility for assessment of vertical cup-to-disc ratio and glaucomatous damage.[4,8–12] In each case intraobserver agreement was significantly better than interobserver agreement, indicating that observers are more likely to agree with their own assessment than others'.

Training of these optometrists resulted in very good agreement for estimation of vertical cup-to-disc ratio and good agreement for assessment of neuroretinal rim configuration, cup shape, vessel path, and final classification of disc appearance. It seems likely that the poorer agreement for evaluation of disc size is due to the new method of assessment used.

We are now investigating the effect of training in these parameters, and systematic evaluation of the disc using standardised criteria, on glaucoma detection in the community.

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