INTER-OBSERVER VARIATION IN CLINICAL OPTIC DISC BIOMETRY

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SUMMARY

This study investigated the inter-observer reproducibility of measurements of the optic nerve head as carried out with a clinical optic disc biometer. This instrument employs a modification of indirect ophthalmoscopy to enable measurement of fundus structures. Measurements were made independently by two observers on 84 eyes of 47 patients. The median inter-observer differences for each measurement were as follows: maximum disc diameter, 0.085 mm; minimum disc diameter, 0.080 mm; maximum cup diameter, 0.098 mm; minimum cup diameter, 0.078 mm; disc area, 0.225 mm^2; neuroretinal rim area, 0.215 mm^2. Utilising the above measurements, the instrument automatically calculates a 'rim index' to take account of variations in disc size. It then interprets the disc as normal, suspicious or glaucomatous. The optic disc biometer produced seriously conflicting interpretations in 8 discs, 7 of which had been judged by both observers to have indistinct boundaries of the disc or cup.

Before any novel analytical technique can be embraced as useful it is important to establish its measurement reproducibility. Where operator subjectivity is a significant factor it is particularly important to evaluate both intra-observer and inter-observer variability. Recently one of us (D.M.) has described a new method of making measurements of structures at the posterior pole of the fundus.[1] In examination of the optic nerve head, intra-observer variability of measurement has been shown to be acceptable and the method shows promise for the detection of glaucomatous damage.[2,3] This technique of optic disc biometry is essentially a modification of indirect ophthalmoscopy whereby an optical spacer allows a fixation target to be introduced at the principal plane of a 15 dioptre condensing lens. With steady fixation maintained, it is possible to make measurements of the ariel image formed at this plane. The technique has now been refined in the development of the optic disc biometer. This instrument employs electronic digital calipers which enter the disc image measurements directly into a microprocessor unit that then automatically calculates the real disc and cup dimensions (see Fig. 1). From these data it calculates values for the disc, cup and neuroretinal rim areas. By comparing the measured rim area with the rim area expected in a disc of a given size the biometer interprets the disc as normal, suspicious or glaucomatous.

To date the technique has been used only by its innovator. The purposes of this study were to assess how easily it could be mastered by a 'novice' and to determine the level of agreement that could be obtained between the two observers.

MATERIALS AND METHODS

Eighty-four eyes of 47 patients were independently examined by two observers (D.M. and A.P.) using the optic disc biometer. Patients were recruited from general outpatient clinics and a wide range of ocular diagnoses were embraced. Amongst these were 20 eyes in which a diagnosis of primary open angle glaucoma had been established and a further 8 eyes with ocular hypertension. The

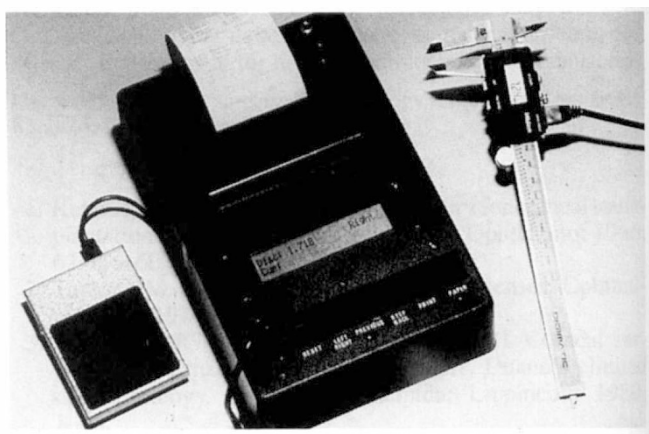

Fig. 1. *The optic disc biometer.*

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mean refractive error was +0.65±2.45 dioptres (range −8.00 to +6.00 dioptres). Eyes were excluded if mydriasis was insufficient to allow a stereoscopic view of the posterior pole, if they had significant media opacity or if they were unable to maintain fixation. All patients were given a full explanation of the examination to be carried out and their consent was obtained. No discussion of diagnosis was entered into prior to the examination, but following the procedure each observer made an independent evaluation of the subjective difficulty of the test. This depended primarily on the definition of the boundaries of both the disc and cup and was graded from 1+ (very easy) to 4+ (very difficult).

Each observer made four measurements on each eye, namely the maximum and minimum diameters of both the disc and its cup. Each set of measurements took about 1 minute to complete per eye. By pressing a footswitch, these measurements were entered directly to the microprocessor unit which then calculated the disc, cup and neuroretinal rim areas according to the formulae given elsewhere.[2]

A further derived value was also calculated, namely the 'rim index'. This is a recently described concept which allows the rim area to be expressed in a form which takes account of the disc size.[3] Several studies have shown that there is considerable variation in disc size and neuroretinal rim area among normal eyes but that there is a good correlation between the size of the disc and the area of the neuroretinal rim.[4–6] It is therefore possible to predict the rim area expected in a healthy disc of a given size. The ratio of the measured rim area to this expected area defines a 'rim index' which may be a useful indicator of neural tissue loss.

RESULTS

Regarding the subjective impressions of the difficulty of individual examinations, there was close agreement between the two observers with no disagreement greater than one place on the linear scale. Where there was disagreement, the higher value is quoted. The number of eyes in each category is shown in Table I. It can be seen that a minority of examinations (32/84) were considered to fall into the easier categories of 1 or 2.

The degree of inter-observer difference for the various parameters is shown in Fig. 2. For each histogram the median value for each parameter is given, as is the median inter-observer difference of the measurements. The median percentage difference is calculated by dividing the latter by the former and multiplying the result by 100. Fig. 2a and 2b show the values for the measurements of the maximum and minimum diameters of the optic disc. The median differences in each case were 0.085 mm and 0.080 mm respectively. These correspond to percentage differences of 4.45% and 4.79%. Fig. 2c and 2d show the values for the maximum and minimum cup diameters. Here the differences were 0.098 mm and 0.078 mm. As the absolute cup diameters were relatively small, the corresponding percentage differences rise to 13.2% and 11.0%.

Table I. Grading of discs according to subjective difficulty

Disc grading	Number
1	7
2	25
3	33
4	19
	84

From the four measurements above, the microprocessor unit calculated the disc and neuroretinal rim areas. Fig. 2e and 2f show that the median inter-observer differences for these parameters were 0.225 mm^2 and 0.215 mm^2, corresponding to percentage differences of 8.63% and 10.9% respectively.

Given the importance of the derived 'rim index' value we have afforded this particular scrutiny. Fig. 3a shows the overall inter-observer difference in 'rim index'. The median percentage difference was 8.23%.

The optics of the indirect ophthalmoscope dictate that the position of the condensing lens relative to the patient's eye may affect the magnification of the image.[7] This becomes particularly significant when the refractive error of the eye is greater than 3 dioptres from emmetropia.[2] Fig. 3b illustrates separately the inter-observer differences in calculated 'rim index' in eyes with errors less than and greater than 3 dioptres. The results of the two groups were not found to differ significantly (two-sample *t*-test; $P=0.16$). Fig. 3c and 3d subdivide the eyes according to subjective difficulty of examination. As might be expected, inter-observer differences were lower in categories 1 and 2 compared with categories 3 and 4 (two-sample *t*-test; $P=0.0045$).

The most critical inter-observer variation relates to the diagnostic classification of the optic discs. Fig. 4 is a matrix illustrating the diagnostic agreement between the two observers. Perfect agreement was found in over 70% of cases. It is perhaps more meaningful, however, to consider the cases in which there was serious diagnostic disagreement, i.e. where observer 1 calculated a disc to be normal while observer 2 calculated it to be abnormal. This occurred in only 8 eyes (9.5%), 7 of which were in the difficult categories of 3 or 4.

DISCUSSION

Accurate assessment of the integrity of the optic nerve head is an essential part of the evaluation of any patient suspected of having glaucoma, yet it is a task fraught with difficulty. In 1967 Armaly[8] popularised the concept of the cup/disc ratio and this is still widely used. Many workers have, however, expressed unease with the degree of confidence placed in such estimations. Kahn *et al.*[9] confirmed suspicions that there is a high degree of inter-observer variability in the estimation of the cup/disc ratio and surprisingly found that training sessions designed to standardise parameters actually worsened this trend. They also reported wide diagnostic disagreement between experts

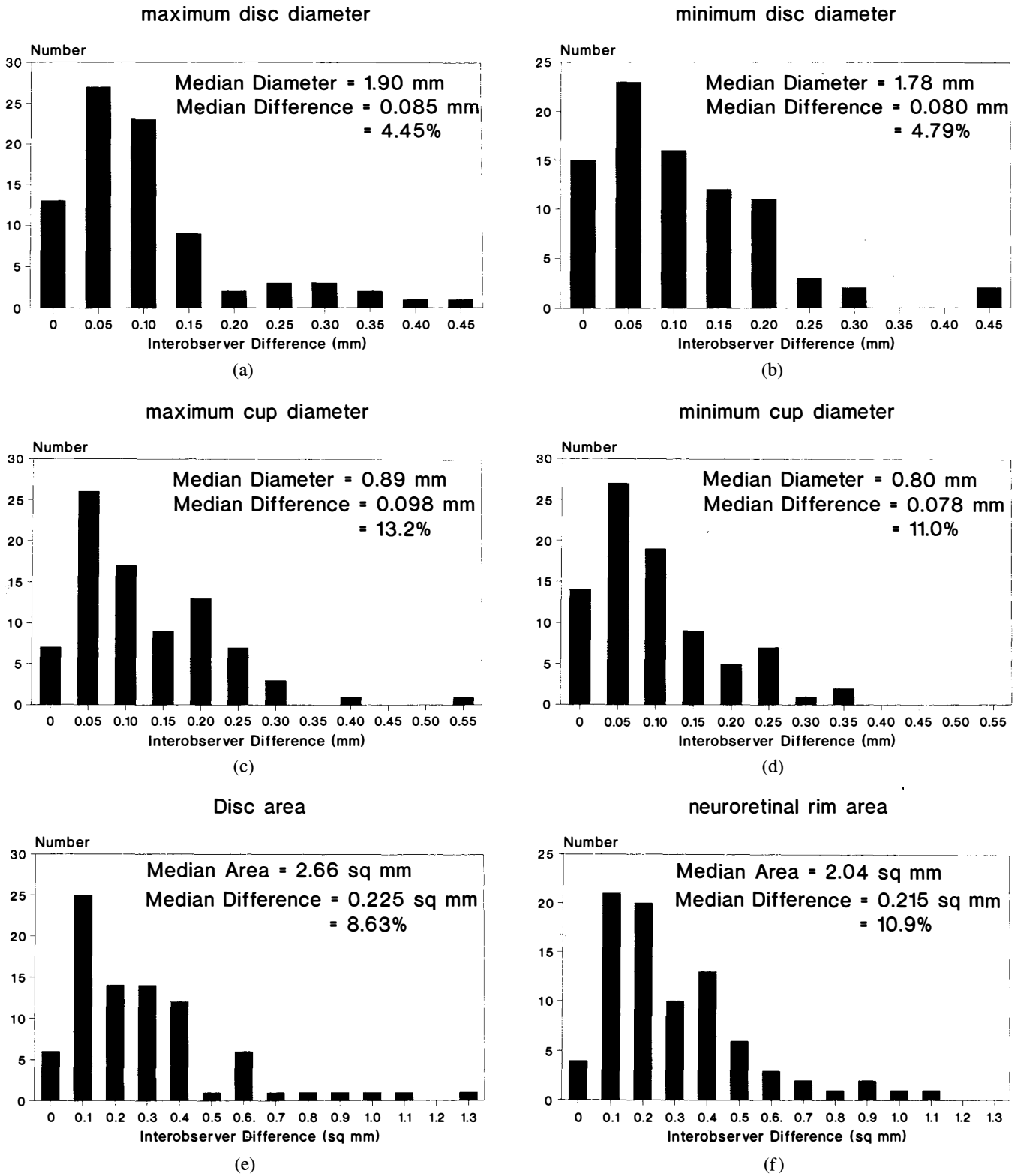

Fig. 2. *Inter-observer differences for measurement of disc and cup diameters, and disc and neuroretinal rim areas.*

and, paradoxically, even when there was tighter agreement on higher values of cup/disc ratio, this was not reflected in agreement that a disc was glaucomatous. Clearly there is a highly subjective element to this method of assessment, which has led Lichter[10] to conclude that 'Cup/disc ratios are an inexact method of recording the status of a disc.'

It has been suggested that loss of over 20% of axons is required to produce a 5 dB decrease in threshold across the visual field.[11] This decrease is reflected in a reduction in the area of the neuroretinal rim. Attention has therefore focussed on the measurement of this parameter as a possible discriminator between normal and glaucomatous discs.[12–15] Other workers have, however, questioned its value in view of its wide normal range and the overlap

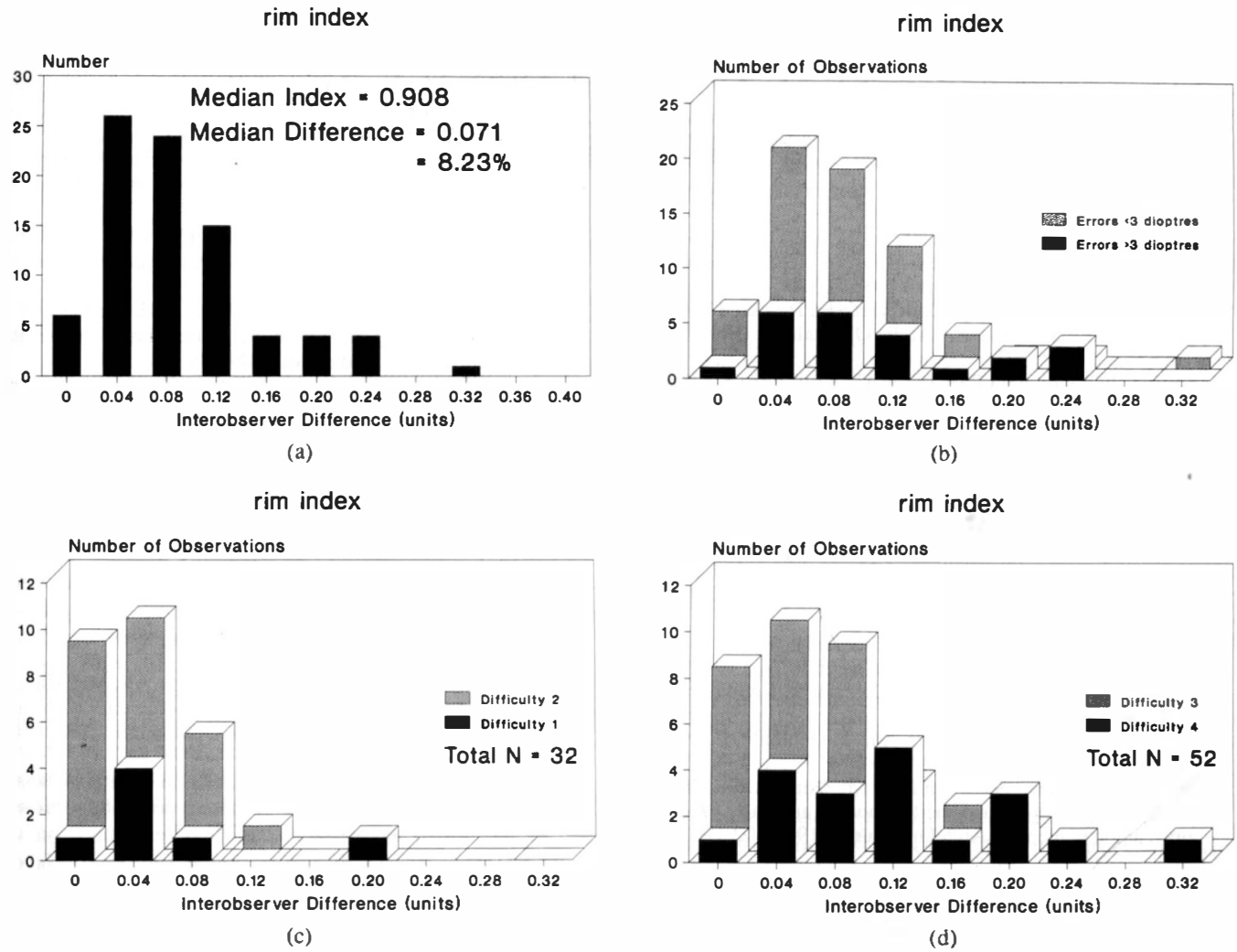

Fig. 3. *Inter-observer differences for calculation of rim index: (a) overall results, (b) according to refractive index, (c, d) according to subjective difficulty.*

with the glaucomatous population.[16–18] This wide range is a consequence of the even greater normal range of disc area.[19] Since the calculation of the 'rim index' takes account of the correlation of rim area with disc area and effectively compares the rim area with that of an 'idealised standard' of similar disc size, this parameter might be expected to have greater discriminating value.

		Observer 1		
		N	G	S
Observer 2	N	41	[1]	3
	G	[7]	18	8
	S	3	2	1

Fig. 4. *A matrix illustrating diagnostic variation between the two observers. N, normal; G, glaucomatous; S, suspicious. Cases of serious diagnostic disagreement are highlighted.*

Table II. Inter-observer variation compared with literature reports of automated disc analysis

	Interobserver variation	
Reference	Disc area (%)	Neuroretinal rim area (%)
Present study	8.63	10.9
[a]Caprioli *et al.*[20]	6.2	7.7
[a]Shields *et al.*[21]	—	6.1
[b]Varma *et al.*[22]	—	5–21[c]

[a]Rodenstock optic nerve head analyser.
[b]Topcon IS 2000 system.
[c]Variability differed depending on individual disc configurations.

In an attempt to improve objectivity of assessment, automated techniques of optic disc analysis have been advocated.[20–22] The degree of inter-observer variability in clinical disc biometry compares quite favourably with equivalent observations with these highly sophisticated methods (Table II). Refractive error appeared to have relatively little influence on the inter-observer variation while the lack of definition of the disc and cup boundaries was a limiting factor in some cases.

Key words: Glaucoma, Measurement, Optic disc, Variability.

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