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Validation of a photographic method of measuring corneal diameter

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SUMMARY A photographic method for measuring corneal diameter using the Medical-Nikkor f 200 mm lens is described. Measurements were compared with those obtained by calipers (46 eyes of 25 patients) and by placing a ruler either near the eye (123 eyes of 64 patients) or on the nose (98 eyes of 55 patients). Over all we found good correlation between photographic and caliper measurements (r=0·94). No significant correlation was found between photographic measurements and estimates made with the ruler either near the eye or on the nose (r=0·65 and 0·31 respectively). Modifications to our system are suggested which may provide an accurate, simple, non-invasive method of measuring corneal diameter in ophthalmic clinics.

The measurement of corneal diameter is an essential part of monitoring the progress of congenital glaucóma during infancy and early childhood. It is also of value in quantifying corneal size in congenital or acquired anomalies of the globe and in quantifying corneal growth.

Three methods of measurement are available: first, by placing a ruler near the eye; secondly, a direct caliper reading from the cornea; thirdly, by using a slit-lamp attachment. For infants and young children neither the second nor third methods are generally applicable.

There have been several reports of previous attempts to develop an alternative to the use of calipers for measurement of corneal size.[1-3] Both Aizawa and co-workers[1] and Kikkawa[2] employed photographic techniques. The former used a fixed focus camera and measured the corneal diameters in 40 children (up to 6 years) but did not compare their results directly with values obtained by standard techniques. Kikkawa used a camera of variable focus to photograph both the eye and a plastic ruler to provide a permanent record for the notes.

This series of experiments was designed to validate the use of a photographic technique, which could provide a simple non-invasive method of monitoring corneal diameter while also providing a permanent record for follow-up of cases.

*Information supplied by Nikkon, UK Ltd, and confirmed by a series of preliminary experiments.

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Patients and methods

APPARATUS

A Medical-Nikkor f 200 mm lens attached to a Nikkon F1 camera back was used to obtain photographic records of the eye. The Medical-Nikkor Auto 200 mm f/5.6 lens was designed for taking close up photographs of known reproduction ratio with the minimum of time and trouble. It is a fixed focus lens with a reproduction ratio of 1:15. Use of an auxiliary lens altered this ratio to 1:1. Focusing is achieved simply by pointing the camera at the eye and moving it back and forth until the eye is in sharp focus. The output of the ring flash was filtered by a combination of EE and 30 CC Blue filters (Kodak Wratten), which effectively block all UV light emitted by the flash.

Fast film (Kodak TMX Professional, ASA 400) was loaded so that the exposure duration could be kept to a minimum. An aperture of f 32, which in combination with the ×1 auxiliary lens produces a depth of field of ±1·86 mm* that is the eye was only in focus when the distance lens to eye was in the range 219·14 to 222·86 mm. The lens to subject distance was 221 mm with this combination of lenses, and the subject field was 24 by 36 mm.

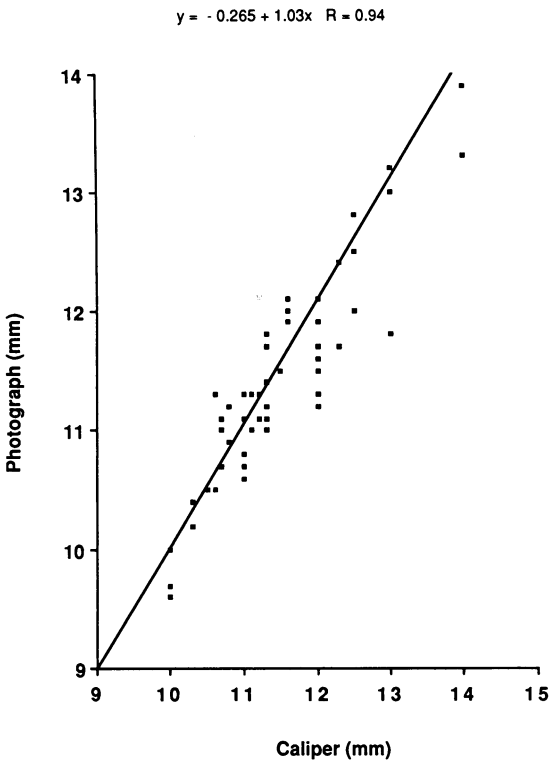

Fig. 1 *Scattergram and linear regression for the photographic corneal diameter measurements compared with the caliper measurements. Solid line, regression line of photographic measurement on caliper measurement (y=−0·265+1·03x with r=0·94).*

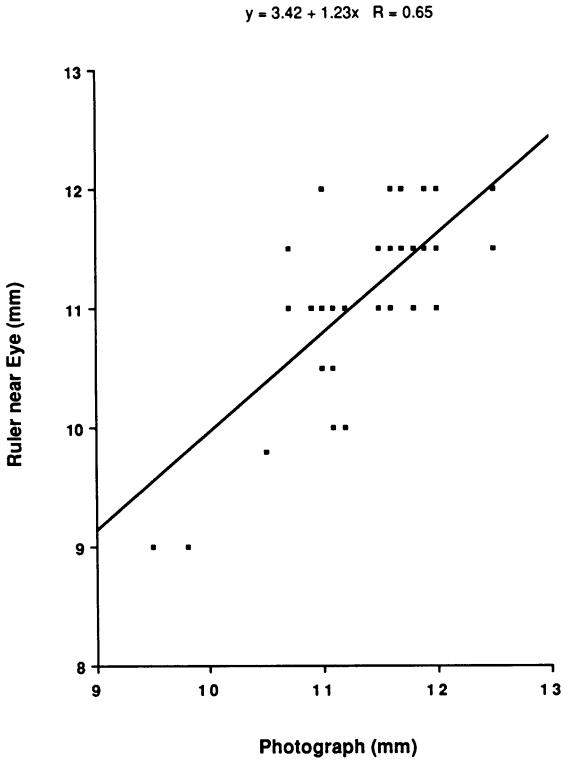

Fig. 2 *Scattergram and linear regression for the photographic corneal diameter measurements compared with measurements made with the ruler near the eye. Solid line indicates the regression line of ruler measurement on photographic measurement (y=3·42+1·23x with r=0·65).*

PATIENTS

Comparison of photographic and caliper measurements. Paediatric and adult patients (46 eyes from 25 patients) undergoing ophthalmic surgery were examined in this part of the study. Measurements were taken while they were under general anaesthesia and prior to commencing the procedure. A photograph was taken, and a second investigator then measured both the horizontal and vertical corneal diameters (white-to-white) using a caliper and rule.

Comparison of photographic with ruler measurements. Corneal diameters of patients attending the Ophthalmic Department of the Leicester Royal Infirmary were measured with a plastic ruler by an ophthalmologist. Each eye was subsequently photographed by a second investigator. Two series of records were made: in the first the ruler was positioned on the patient's nose (123 eyes from 64 patients), and in the second the ruler was placed near the eye (98 eyes from 55 patients).

Measurement of corneal diameters from photographic records. Films were processed by a modification of the fluorescein process to minimise grain size on the negatives. Two observers then independently measured the horizontal and vertical visible iris diameters directly from the negatives using a magnifying scale lens (peak scale loupe ×7).

ANALYSIS OF RESULTS

Correlation coefficients, Student's paired *t* test, and analysis of least squares were used to analyse the statistical significance of the data. Because measurements were carried out on right and left eyes, there may be some interdependence of measurements of the data. However, any such interdependence of measurements of right and left eyes was not expected to interfere critically with the design of the study. Therefore we treated the measurements of both eyes independently in the statistical analysis.

Results

There was good overall correlation between the

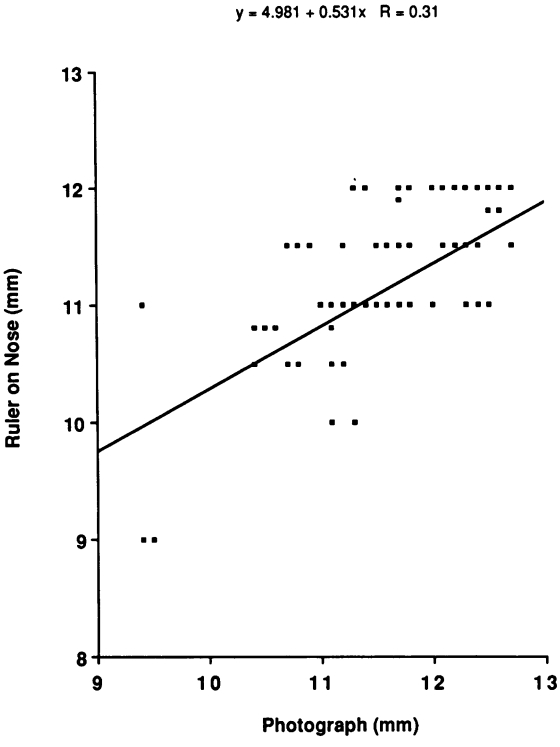

Fig. 3 *Scattergram and linear regression for the photographic corneal diameter measurements compared with measurements made with the ruler on the nose. Solid line indicates the regression line of ruler measurement on photographic measurement (y=4·98+0·53x with r=0·31).*

caliper and photographic methods (r=0·94). The deviation from zero correlation was tested by a paired *t* test (*t*=2·04), which was not significant at the 0·05 level with n−2 degrees of freedom. Fig. 1 shows a scattergram and linear regression for the photographic corneal diameters compared with the caliper measurements. The linear regression line was:

$$\text{Photo} = -0{\cdot}265 + 1{\cdot}03 \text{ caliper.}$$

The standard error of estimate of this linear regression was 0·07 mm.

This analysis showed that there were no significant differences between the estimates of corneal diameter obtained from calipers or photographs ($F=204{\cdot}271$, $p<0{\cdot}0001$). Good interobserver agreement was noted (r=0·97) between measurements of corneal diameter obtained from the photographic records.

When the photographic estimates were compared with those obtained by a plastic ruler placed near the eye (Fig. 2) or on the patient's nose (Fig. 3) no significant correlation was noted (r=0·65 and r=0·31 respectively).

Discussion

These results show that caliper and photographic measurements of corneal diameter correlate well. Photographs have several advantages over both caliper and ruler measurements. Firstly, they are simple to perform and do not require the use of a general or topical anaesthetic. Secondly, they provide a permanent record which may be of practical use in monitoring the progress of certain ocular conditions.[2] Finally, the photographic method is more accurate: diameters may be measured to the nearest 0·05 mm from the photographs compared with ±0·25 mm with calipers or ±0·5 mm with a ruler. A further unknown aspect is observer bias, as most adult corneal diameters fall within a known narrow range. The ruler 'measurement' is the combination of this ruler finding and qualitative clinical assessment. In the absence of this last clue it is probable that ruler measurements would show considerably more variation.

At present when the corneal diameter is measured in an infant or child clinic it is estimated by placing a ruler near the eye. Not surprisingly our results suggest that the positioning of the ruler affects the estimate of cornea size (see Figs. 2 and 3). Perhaps parallax errors may explain low correlations found between measurements taken when the ruler was placed on the nose and photographic estimates. However, on this principle we would have expected ruler measurements to have consistently overestimated those obtained photographically, and this was not the case.

The question remains as to the practical implication of these findings for the clinical measurement of corneal diameters. Slight modifications to the photographic system which was used in this research could provide a simple non-invasive method of measuring corneal size. One option would be the use of Polaroid film; together with adaptor rings it may be possible to attach the Medical-Nikkor lens to a substitute camera back. Alternatively, use of the magnifying lens could be avoided by loading a technical film (preprinted with a scale), though such films must be processed in the standard way.

Knowledge of corneal size can be useful in a variety of clinical circumstances, including the management of congenital glaucoma and, in the adult, when trying to ascertain whether the pathological process was of early onset or after the first year of life and completion of corneal growth. This technique also has considerable potential in the study of corneal growth.

Judith Robinson is a Royal National Institute for the Blind research student. Ethical permission for this study was granted by the Leicestershire Area Health Authority.

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