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THE USE OF ULTRASOUND IN OCULAR BIOMETRY

KUAN BEE BEE
LIM THUNG KIAT

SUMMARY

Ultrasound measurement of ocular dimension is the chosen method for assessing axial length when determining dioptric power for intraocular lens. From the current results of 30 cases studied, the mean axial length ranges from 22 to 23 mm. Despite the limitation of the accuracy of the ultrasonic measurements with the 7.5 mHz transducer, the power of intraocular lens can be determined satisfactorily in accordance with the knowledge of keratometric reading. Hence, high refractive errors could be avoided post-operatively.

INTRODUCTION

Ultrasound provides rapid, objective and accurate measurement of ocular dimensions: In their series, Leary[1] and Sorsby[2] found that ultrasound technique is the preferred method with comparing optical, ultrasonic and radiographic measurements. With the increased demand of better aphakic optical correction with intraocular lens, the need is becoming apparent for a more accurate and better method for the determination of lens power, than the empirical method or the method utilising past refractive history. The authors have been using ultrasound at the Department of Radiology, University Hospital Kuala Lumpur, since the middle of 1983 for measuring the axial length of the globe for the purpose of determining dioptric power of intraocular lenses during pre-surgical preparation.

Kuan Bee Bee,MBBS(S'pore),DMRD(Lond),FRCR(UK)
Lecturer
Department of Radiology
Faculty of Medicine
University of Malaya
Kuala Lumpur, Malaysia

Lim Thung Kiat,MBBS(S'pore),DO(Lond),FRCS(Glas)
Lecturer
Department of Ophthalmology
Faculty of Medicine
University of Malaya
Kuala Lumpur, Malaysia

MATERIALS AND METHODS

Thirty eyes of 27 patients from the Department of Ophthalmology, University Hospital Kuala Lumpur, were included in this study. The ultrasound machine used was the Technicare EDP 1200.

Ultrasound measurements were collected with the immersion technique which involved a simple water bath consisting of a plastic bag containing tap water in contact with the globe. This method was employed by the Birmingham and Midland Eye Hospital, United Kingdom, while one of the authors (LTK) was working there as a resident. It was found to produce satisfactory image with the Technicare Ultrasound Machine EDP 1200 and all the results in the present study were obtained with this method. A 7.5 mHz probe was used as this was the highest frequency probe available in the Department. Ideally a 10 mHz probe would produce more accurate results.[3]

The procedure was explained briefly to the patient. A drop of 0.5% amethocaine was instilled into the eye for anaesthesia. To create a water bath, a plastic bag with an adhesive part was used. An elliptical-shaped opening was made in the adhesive part and this was pressed firmly around the eye to create a good seal in order to prevent water leakage. An opening was then made in the plastic bag through which water could be poured. The patient was instructed to close both his eyes while the bag was being filled with water. When at least 3 cm depth of water over the eye was obtained, the patient was told to open his eyes and instructed to look straight up at a point on the ceiling. Transverse scans were then done as it was easier to locate the lens in this plane.

At least three satisfactory scans were taken and the highest of the three readings of the axial length, if they were different, was recorded. Axial length was registered to the nearest millimeter. This resulted in limiting the accuracy of the assessment of the ocular dioptric system. However, as demonstrated in the present study for the assessment of ocular refraction it provided useful information. Keratometric readings were obtained with Bausch and Lomb Keratometer and the nearest dioptre of the average power of the two meridians was recorded.

Several technical points have to be observed during scanning. The transducer beam should be properly aligned along the axis of the globe and a scan would be judged satisfactory if the cornea, iris, lens and posterior retina of the globe were obtained. The immersion technique should give distortion free measurement whereas with the contact method, which involved scanning on a water bag over the closed eye, compression of the globe would give inaccurate readings. A high frequency transducer able to produce the desired depth of penetration should be used to obtain the greatest accuracy. This is best achieved with a 15 or 20 mHz frequency transducer.[3] Although a 7.5 mHz transducer was used in this study, it was found that the results obtained were satisfactory for the present purposes.

RESULTS

A typical B-scan ultrasonogram along an axial scan plane is illustrated in Fig. 1. The cornea appears as an acoustically bright curved band. The anterior chamber shows up as an uniformly acoustically clear (black) area. The echoes of the iris merges with those of the anterior lens surface. The interior of the lens appears as an acoustically homogenous space. The posterior curvature of the lens is usually well demonstrated. The vitreous compartment usually appears as an echolucent cavity with no internal sound reflection and the vitreoretinal interface appears as a smooth concave curvature.

Table I shows the results obtained from 30 eyes. The operations consisting of cataract extraction with or without anterior chamber lens implantation were performed between May 1983 and May 1984. Three of the 27 patients had scanning done in both eyes (a, b). One of them (Case 4, Fig. 2) was advised against intraocular lens implantation because of high axial myopia[4] and no significant optical advantage would be obtained in comparison with spectacles correction. His pre-operative refraction was −6.00 dioptres (spherical equivalent) in either eye before the development of steroid induced cataract. Keratometric readings were obtained to two decimal places and they were recorded to the nearest dioptre because of the limitation of axial length measurement. The range of keratometric reading was from 42 to 47 dioptres, and 22 out of 30 eyes (73%) were between 43 and 45 dioptres. The range of axial length was 21 to 28 mm, and 18 out of 30 eyes (60%) were either 23 or 22 mm.

The post-operative refraction ranged from −5.00 to +1.50 dioptres. The post-operative refraction recorded was obtained at least two months after the operation (except Case 6b), and the longest duration was 11 months. Initially, an intraocular lens of power +19 dioptres was implanted if the past refractive history was emmetropic, and ultrasound axial length served as a guide, provided the keratometric reading was not 3 dioptres higher or lower than the normal (i.e., 43 dioptres), and the axial length was within 2mm range of the normal (i.e ,23mm).[5]

TABLE I
RESULTS OF THE TESTS CARRIED OUT ON 30 CASES

Case Number	Date of operation	Keratometric reading (neares dioptre)	Axial length (mm)	Post-operative refraction (spherical equivalent) and duration after operation (mths)	Power of intraocular lens (dioptre)
1a	May '83	45	23	−4.00 (11)	+19
1b	May '83	45	24	−5.00 (11)	+19
2	Sept '83	43	24	−1.50 (8)	+19
3	Oct. '83	44	24	+0.50 (8)	+19
4a	Oct. '83	43	28	+5.50 (5)	No IOL
4b	Oct. '83	42	28	+5.25 (5)	No IOL
5	Oct. '83	43	25	−4.00 (8)	+17
6a	Oct. '93	44	22	+1.25 (4)	+19
6b	May '84	44	22	+1.40 (4)	+19
7	Nov. '83	47	22	−0.25 (3)	+19
8	Nov. '83	43	23	+0.25 (7)	+19
9	Nov. '83	42	24	−2.75 (8)	+19
10	Nov. '83	43	24	−1.50 (7)	+19
11	Dec. '83	45	24	−4.25 (7)	+19
12	Dec. '83	46	23	−2.00 (2)	+19
13	Dec. '83	43	22	+1.50 (6)	+19
14	Dec. '83	46	23	−1.50 (7)	+19
15	Dec. '83	45	22	+1.25 (4)	+19
16	Feb. '84	45	22	+1.50 (5)	+17
17	Feb. '84	45	22	+0.50 (2)	+19
18	Feb. '84	47	21	+1.50 (3)	+17
19	Feb. '84	43	23	Plano (4)	+17
20	Feb. '84	45	22	−1.50 (4)	+19
21	Feb. '84	43	22	−0.50 (4)	+21
22	March '84	46	23	−3.00 (3)	+19
23	March '84	46	21	+0.25 (2)	+19
24	March '84	44	22	−0.50 (3)	+19
25	March '84	43	22	−0.50 (4)	+19
26	March '84	44	23	−0.75 (4)	+19
27	April '84	44	22	−1.75 (2)	+19

Note Before: No IOL = No Intraocular Lens; a, b = eyes of the same patient.

Fig. 1 **A typical B Scan ultrasonogram illustrates echoes from cornea, iris, lens and retina.**

Fig. 2 **B Scan ultrasonogram of Case 4 with an axial length of 28 millimeters.**

DISCUSSION

Ultrasonography is used for accurate biometry of the eye. It is also essential for clinical evaluation of eyes with opaque media due to cataract, haemorrhage, inflammation, corneal scarring, for assessment of suspected intraocular tumours and for orbital soft tissue tumours or inflammatory congestive changes.[3]

Diagnostic ultrasound was first described for the eye in 1956 by Mundt and Hughes[6] using A-scan technique which is one dimensional in nature. Two-dimensional ultrasonic imaging (B-scan) was introduced in 1958 by Baum and Greenwood.[7] The method was developed and a practical water immersion system with simultaneous displays of A-scan and two dimensional B-scan was produced.

Commonly used frequencies for ultrasound in ophthalmology are 8 to 10 mHz although 15 or 20 mHz are used for higher resolution and biometry.[3] The clinical procedure of ultrasonic measurement of axial length is convenient and acceptable to both subject and examiner. Low intensity ultrasonic methods produce no harmful effects on ocular tissue.[8] In the present study, several difficulties were encountered in obtaining the axial length readings. Leakage of water from the water bath not only prevented the authors from obtaining the reading but also soaked the patient thoroughly. Absorbent cloth was kept ready to overcome this. Fortunately, the leakage seldom occurred after gaining experience in setting up the water bath. The ultrasound image of Case 14 was consistently blurred and unsatisfactory. After several attempts, the longest axial length of the best image was recorded. The post-operative refraction was −1.50 dioptre seven months after the operation. The cause of blurring was not known. A common artifact encountered was reduplication echoes. These have been analysed by Kossoff.[9] This is the result of echoes rebounding from the transducer to the eye for a second or a third trip. Fig. 3 is an example of this artifact. An echo of this type is often seen in the mid-vitreous, if the transducer is positioned a short distance from the eye. They can be detected easily by moving the transducer closer or further away from the eye. Real echoes do not move with the transducer. To the inexperienced, these may represent retinal detachment. This ultrasound method is not accurate enough for measuring the anterior chamber depth because the depth is about three millimeter and the ultrasound machine could only register to the nearest millimeter.

Table I shows that patients with short axial length have correspondingly high keratometric readings but those with long axial length do not have correspondingly low keratometric reading. In fact, the latter keratometric readings are within the mean, i.e., 43 to 45 dioptres. This latter fact is important in the determination of the power of intraocular lens. This also confirms the finding that high myopic eye is the result of the elongation of the posterior segment.[5] As the range of keratometric readings is only five dioptres, and the range of axial lengths varies by 7mm which is equivalent to 21 dioptres,[5] axial length is more important than keratometric reading in the lens power determination.

With the above findings, if anterior chamber intraocular lens of +19 dioptres is implanted for cases with keratometric reading of 45 dioptres and axial length of 22mm, or keratometric reading of 43 dioptres and axial length of 23mm, the post-operative refraction would be ± 1.50 dioptre as

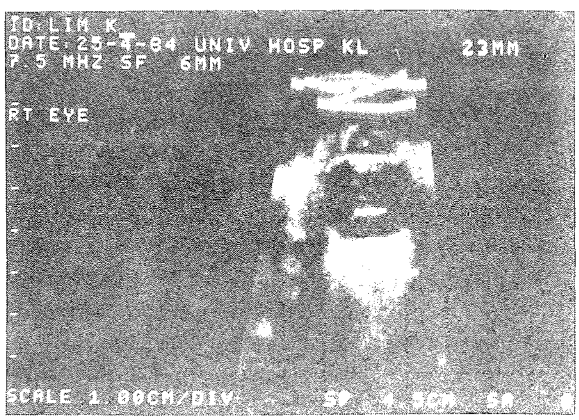

Fig. 3 **B Scan ultrasonogram illustrates reduplication echoes in the vitreous cavity.**

illustrated in the Table. This is a satisfactory result.[10] If the parameters are different from those stated in the guideline mentioned above, the determination of the power of intraocular lens could be calculated in the following way, e.g., for axial length of 22 mm with keratometric reading 43 dioptres, a +17 dioptre implant would be recommended or for a millimeter difference in axial length, 3 dioptre alteration should be made in the +19 dioptre implant. Determination of the lens power with ultrasound axial length and keratometric reading can also be obtained with Binkhorst nomogram.[11]

CONCLUSION

In this study, we have exploited fully the ultrasound facility available in the University Hospital to achieve a satisfactory method of measurement of axial length of the globe. No ocular complication has been encountered with the use of the Technicare Ultrasound machine. The method described allows the implant surgeon to provide a better care for the patient in terms of controlled post-operative refraction.

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