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The pupil cycle time test: age variations in normal subjects

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SUMMARY The pupil cycle time (PCT) was studied in 86 normal subjects aged from 10 to 79 years. The cycle time showed a clear tendency to increase with age. Thus the mean PCT in the group aged from 10 to 49 years was 739±74 ms whereas the mean PCT in the age group of 50 to 79 years was 872±83 ms. Only 2% of eyes from the group aged from 10 to 49 years had a PCT above 954 ms, while 23·9% had a PCT longer than 954 ms in the elder patients' group (60–79 years). The presence of miosis and marked senile changes in the iris of several elderly patients must be kept in mind, and the prolonged PCT results must be interpreted with caution in this age group. On the other hand a rapid PCT rate in elderly patients is significant as predicting good optic nerve function. In all age groups the criteria for normality of PCT are: correlation with the usual findings for the patient's age group, a small variation of PCT with repeated measurement in the same eye, and a small difference in PCT values between eyes.

The ability to assess the speed of optic nerve conduction during slit-lamp examination has obvious advantages. The recording of visually evoked potentials (VEP) has provided ophthalmology with an objective electrophysiological means for studying the visual processes in man. However, as noted by Sokol,[1] 'The equipment necessary for V.E.P. work is cumbersome and expensive and technical skills required to assemble the equipment are usually not part of the practising clinician's repertoire.' Recently Miller and Thompson[2 3] established a method by which the edge-light pupil cycle time (PCT) can be accurately studied during the slit-lamp examination. With this method a slit of horizontal light focused at the pupillary margin induces oscillations of the pupil as it contracts to light (leaving the light area) and then redilates in darkness. When the efferent part of the light reflex of the pupil is normal, determination of the period of these cycles in milliseconds (ms) provides a number which may be correlated with conduction time in the anterior visual pathways. This measurement can be made in the practitioner's office, thus making possible a better selection of cases requiring further examination at a visual research laboratory.

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In order to establish criteria for normality of the PCT, Miller and Thompson[2] studied 50 normal subjects aged between 12 to 50 years. They found a mean PCT of 822±69 ms in the group as a whole. There was a PCT longer than 954 ms in only 5% of this normal population. A difference in PCT longer than 70 ms between both eyes was also found in only 5% of this age group. These authors also noted that normal subjects over the age of 50 years showed a clear tendency to have a longer PCT, but since they had tested only 8 such subjects they drew no definite conclusions, suggesting that this required further study.

In the present study we measured the PCT in normal subjects belonging to different age groups ranging from 10 to 79 years.

Materials and methods

The subject material comprised of 86 normal persons aged between 10 to 79 years who were divided into different groups according to age (Table 1). All of the eyes included in this study had normal visual acuity, confrontation fields, pupillary reflexes, and ocular tension; ocular fundi were in accordance with age, and no lesion of the optic nerve head was visible in any case. The patients were not receiving drugs, and among the elderly ones we excluded those with very

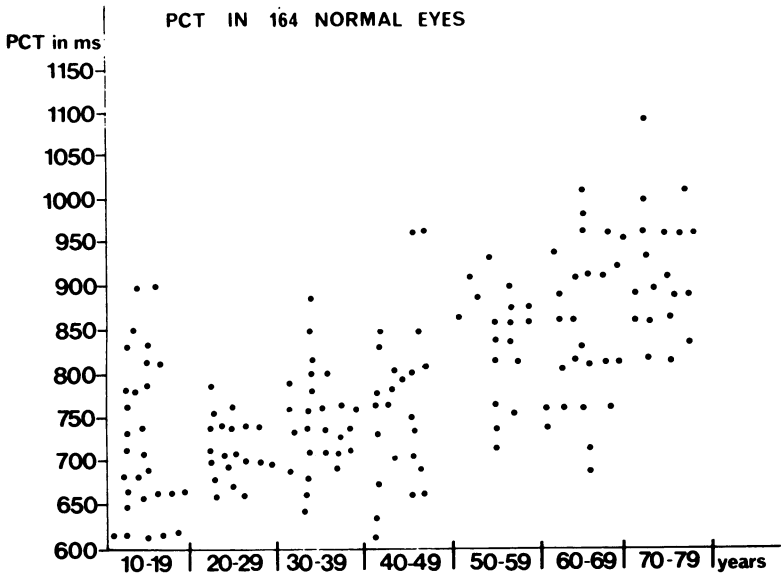

Fig. 1 *Distribution of PCT of 164 eyes of normal subjects in decades of age.*

pronounced senile miosis or marked senile pupillary changes which did not allow the minimal pupil mobility necessary for the test.

Among the patients accepted for the study we excluded their eye that presented monocular disease if this was the case or those eyes with cataract which prevented good visibility of the optic nerve head or with aphakia which might interfere with the integrity of the pupillary sphincter. Thus in 36 patients aged 50–79 years there were 8 in whom only one eye was included in the study.

The method of testing PCT was that described by Miller and Thompson.[2 3] Three cycles of 30 PCT each were measured in each eye with the aid of a hand-held stopwatch of an electronic calculator.

Results

PCT DISTRIBUTION IN DIFFERENT AGE GROUPS

The PCT distribution according to the different age groups and the mean PCT in these normal subjects are presented in Table 1 and Fig. 1. There is an evident tendency for PCT to increase with age. When the population was divided into 2 groups, one including subjects aged between 10 to 49 years and the other including subjects aged between 50 to 79 years, there was a striking difference between the mean values of PCT in the 2 groups. In the age group of 10 to 49 years the mean PCT was 739±74 ms, whereas in the age group of 50 to 79 years the mean PCT was 872±83.

Table 1 *Age distribution and mean PCT of 86 normal subjects*

Age group (years)	*No. patients*	*No. eyes*	*Mean PCT*	*SD*
10–19	15	30	728	88
20–29	10	20	717	34
30–39	13	26	748	56
40–49	12	24	761	91
50–59	10	18	838	62
60–69	14	27	860	89
70–79	12	19	922	71

PCT LESS THAN 800 MILLISECONDS

In the age group of 10 to 39 years (38 patients, 76 eyes) there was a PCT less than 800 ms in 84·69% of the eyes examined in that group. In contrast, in the age group of 50 to 69 years (45 eyes) there was a PCT under 800 ms in only 24·4% of the eyes examined. Among the patients aged more than 70 years (19 eyes) there was no PCT under 800 ms.

PCT LONGER THAN 900 MILLISECONDS

If we consider as a single group all the 100 eyes belonging to 50 normal subjects aged between 10 to 49 years, there is a PCT between 900 and 966 ms in only 4 eyes (4%), with only 2 eyes (2%) having a PCT above 954 ms and no eyes with a PCT above 966 ms. It is of note that in all of the 4 eyes with a PCT between 900 and 966 ms the VEP was normal. The PCT of 954 ms is noted particularly, since this was determined by Miller and Thompson to be the upper border for a normal PCT in 95% of their normal subjects. In contrast to the finding in the younger age group our older subjects, aged between 60 to 79 years, had a PCT between 900 and 976 ms in 16 eyes (34·78%) and a PCT between 1000 and 1100 ms in 4 eyes (8·69%).

Table 2 *Mean PCT differences between both eyes in different age groups of 78 patients*

Age group (years)	*No. of patients*	*Mean PCT difference between both eyes*	*Percent of cases less than 50 ms with difference between both eyes*	*Percent of greater than 70 ms with difference between both eyes*
10–19	15	24·7±7·12	93·33	6·66
20–29	10	26·4±19·89	90	0
30–39	13	43·3±22·4	61·5	7·69
40–49	12	32·83±27·04	83·33	8·33
50–59	8	32±14·3	100	0
60–69	13	31·66±23·68	76·9	0
70–79	7	56±24·22	57·14	14·28

In the patients aged 10–69 years there was a difference in PCT between both eyes greater than 70 ms in only 3 cases (4·22%).

In this group of elderly subjects there were 11 eyes (23·91%) with a PCT longer than 954 ms. The border for a normal PCT in this age group could be considered 1010 ms, since only 4·3% of the examined eyes presented a PCT above this value.

DIFFERENCE IN PCT BETWEEN BOTH EYES

Table 2 presents the mean of the difference in PCT between the 2 eyes in each subject, also in accordance with the different age groups. The mean of the difference between the 2 eyes in the 50 patients aged 10 to 49 years was 29±24 ms as compared with that between the 2 eyes of 28 patients aged 50 to 79 years, which was 36±24 ms. In the group of 71 patients aged 10–69 years there was a difference in PCT between both eyes greater than 70 ms in only 3 cases (4·22%).

Discussion

Miller and Thompson[2] found that beyond the age of 50 years there was a lengthening of the PCT. Dustman and Beck[4] found that in a group of older subjects, with a mean age of 67 years, the VEP test showed a marked delay in the appearance of the earlier components. It is tempting to speculate that this VEP evidence of increased conduction time in anterior optic pathways in elderly patients may suggest a similar reason for the prolongation of PCT with age. However, there are possible subclinical sphincter innervation defects, and the arteriosclerosis and deposition of hyaline in the iris stroma and muscles[5] may produce a slower reaction of the pupil in elderly patients. Then the exact role played in each elderly patient of the afferent versus the efferent pathway of PCT is still an open question.

In the present study we have found a tendency towards a lengthening of the PCT with age in a group of 86 patients aged from 10 to 79 years. Thus the mean value of PCT in the group of subjects aged from 10 to 49 years was found to be 739±74 ms, while in striking contrast was the mean PCT found in the elderly group aged from 50 to 79 years—872±83 ms. The criteria for judging the normality of PCT are summarised in Table 3.

Table 3 *Criteria for normality of PCT*

Age group	*PCT values*		
	PCT<800 ms	*PCT>954 ms*	*PCT>1010 ms*
10–39 years	84·69%		
10–49 years		2% our work 5% Miller and Thompson	No one in our work
50–69 years	24·4%		
70–79 years	No one		
60–79 years		23·9%	4·3%

1. Intact efferent arm of the light reflex: no anisocoria increasing in light; no segmental sphincter palsies; no light near dissociation.
2. Values compared to those most frequently found in the similar group of normal patients are shown in Table.
3. In young patients: (*a*) a PCT value longer than 954 ms is usually of significance, i.e., abnormal optic nerve function; (*b*) a PCT value around 850–900 ms may express normality (if the value is constant for that eye) or may express pathology (if the previous PCT was, for instance, around 700 ms).
4. In elderly patients: (*a*) a PCT value longer than 1010 ms should be interpreted with caution, as it may express efferent pathology as well as iris and/or pupillary defects frequent at this age group; (*b*) a PCT value shorter than 850 ms is usually of significance, i.e., normal optic nerve function.
5. The lack of significant difference in PCT in the same eye over certain periods of time.
6. The lack of significant difference in PCT values between the 2 eyes.

Miller and Thompson[2] took a PCT of 954 ms to be the upper border of normal, since they found that 95% of their subjects who were no older than 50 years of age had a PCT under this value. This may leave us with a diagnostic problem—that of the normality of the PCT in the second eye of a patient with optic neuritis or of a PCT with a conduction delay expressing a subclinical pathology. For example, a PCT of 900 ms in the eye without clinical manifestations may be normal or may be suspected to be pathological if the patient's age is such that he would have been expected to have a PCT under 800 ms from the trend seen in our data. Thus we believe that in certain clinical contexts, as in young patients with unilateral neuritis, the finding of a PCT between 900 to 950 ms in the second eye suggests a possible increase from lower PCT values and perhaps disease. In such doubtful cases the addition of VEP analysis to the examination should be helpful in solving the diagnostic problem and also the repeated PCT measurement of the 'good' eye. In our experience with acute optic neuritis the 'unaffected' eye often has a prolonged PCT, which shortens significantly as the vision in the affected eye improves.

As to the upper limit of the normal value of PCT for patients above the age of 60, our data indicate that this is considerably higher than that in the younger age group, i.e., 1010 ms. This can be explained by

different and often concomitant mechanisms: a delay in the conductability of the afferent arm of the pupil light reflex in elderly (as indicated by the changes of VEP time in aged people); an alteration of the efferent arm of the pupil reflex as shown above; and the presence of the senile miosis which brings small amplitude cycles so difficult to measure in an accurate manner.

Thus the results of PCT in elderly patients should be considered with caution, in the whole context of the clinical picture. On the other hand in elderly groups of patients a PCT value shorter than 850 ms is significant, that is, it usually indicates normal optic nerve function. Another criterion to be used in judging the normality of PCT should be the stability of this value in any one individual. Miller and Thompson[2] found few small variations of the PCT value over certain periods of time in normal subjects aged up to 50 years, the maximum variation in average PCT being ±3%. Thus in a patient suspected of having multiple sclerosis a change in the PCT value of an eye from 900 ms to 700 ms after a certain interval would suggest the presence of a conduction delay during the period when PCT was 900 ms, with the value of 700 ms being found during periods of recovery.

Yet another criterion to be used in establishing whether the PCT found in a patient represents normal conduction time in the optic nerve tissue is the difference between PCT values in the 2 eyes of any individual patient. Our findings also indicate that in normal subjects there should be very little difference in PCT values between the 2 eyes.

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