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The Prism Bar—Prentice and Frontal Positions

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Summary

The prism cover test has been in use for many years for measuring ocular alignment. The measurements obtained are used for both calculating the amount of correction needed in strabismus surgery, and monitoring any change in ocular alignment with recovery from muscle imbalance. Variability may arise from its use in either the frontal position or the Prentice position.

Most prism bars used in the United Kingdom are calibrated for use in the Prentice position. Inaccurate results arise when a prism bar is used in a position for which it is not calibrated. The theoretical calculation for adjusting measurements obtained in the frontal position with prisms calibrated for use in the Prentice position was assessed clinically. A new modified equation is proposed incorporating practical aspects of performing the prism cover test. A table of values is included to assist in determining the necessary adjustment, so allowing for a more reliable assessment.

Some prism bars (PB) in use in the United Kingdom are calibrated for use with their posterior plane surface held normal to the line of fixation (Prentice position).[1] If these prism bars are used with their posterior surface held parallel to the frontal plane and against the supra-orbital margin (frontal position) an error is introduced into the measurement. Thompson and Guyton[2] examined the way the prism cover test (PCT) was performed by orthoptists and clinicians. Three frequently used methods of performing the PCT were found; in the frontal and Prentice positions, and with the PB held in the position of minimum deviation. They discussed the theoretical formula used to calculate the error produced using a prism calibrated in the Prentice position, but held in the frontal position. There are no reports to show whether this theoretical description holds true in practice. To determine the magnitude of this error we studied a group of patients with concomitant horizontal strabismus and measured the deviation in the Prentice and frontal positions. The difference between the two measurements was then compared to the theoretical predicted difference.

The use of prism bars calibrated for use in the Prentice position when used in the frontal position leads to (systemic) over-estimation of angle of (ocular) deviation.

Method

The study was performed in the Orthoptic Department at St Paul's Eye Hospital in December 1987. The PCTs were performed by four experienced orthoptists. In each case two orthoptists were present, one acting as an observer. Sixty-seven patients who were currently under orthoptic supervision were recruited into the study. All patients had concomitant horizontal strabismus measuring less

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than or equal to 45 PD on the major amblyoscope, and stable fixation in each eye. Visual acuities ranged from 6/5 to 6/18. Their ages ranged from 4 to 44 years with a mean age of 10 years. They were randomly allocated into two groups:
Group 1. The PCT was first performed with the PB held in the Prentice position, then with the PB held in the frontal position.
Group 2. The PCT was first performed with the PB in the frontal position, then in the Prentice position.

In order to determine the measurement in the frontal position the PB was held with its posterior plane surface against the supra-orbital margin. The measurement in the Prentice position was obtained by placing the posterior plane surface of the PB normal to the direction of gaze of the eye, and as close to the eye as possible. The PBs used were calibrated for use in the Prentice position. Fixation targets were held at distances of 33 cm and 6 m from the patient. The PB was held in front of the deviating eye and an alternating cover test performed. The PB was adjusted to introduce prisms of increasing strength in front of the deviating eye. The test was continued until a prism was found which just produced a movement in the opposite direction. The value of the prism prior to this over-correcting prism was taken to represent the amount of deviation, and its value recorded.[3] Each PCT was repeated and if the measurements were inconsistent, the mean of the two values was then recorded.

Table I. *Measurements obtained in the Frontal position compared with those obtained in the Prentice position, using a Prentice position calibrated prism bar. SD = Standard deviation, CV = % Coefficient of variation, Number = Number of measurements for each position, Difference = Difference in PD between the frontal and Prentice positions.*

Frontal	*Prentice*	*SD*	*CV*	*Number*	*Difference*
2	2.0	0.0	0	2	0.0
4	4.0	0.0	0	5	0.0
6	5.5	1.0	18	4	0.5
6	5.5	1.0	18	4	0.5
8	7.6	0.9	12	5	0.4
10	8.0	2.0	25	9	2.0
12	10.5	1.8	17	8	1.5
14	13.3	1.0	8	6	0.7
16	14.2	1.4	10	11	1.8
18	16.0	1.4	9	5	2.0
18	16.0	1.4	9	5	2.0
20	17.4	1.7	10	17	2.6
25	20.1	2.7	13	18	4.9
30	23.2	2.8	12	12	6.8
35	29.4	1.8	6	8	5.6
40	31.4	3.2	10	11	8.6
45	35.8	2.8	8	13	9.2

Results

Table I shows the results of the PCT performed in the frontal and Prentice positions. Column one shows the measurements in the frontal position, ranked in ascending order as on the PB. Column two shows the corresponding mean results obtained in the Prentice position. Column three shows the standard deviation about the mean for the measurements obtained in the Prentice position. The percentage coefficient of variation is shown in column four, with the number in each group in column five. Column six shows the difference between the mean of the Prentice and the corresponding frontal position measurement.

The results from the four orthoptists were analysed and no statistically significant difference between the four was found.

When the PB is held in the Prentice position the total deviation (Vp) takes place at the first refracting surface (Fig. 1) and is given by 100Tan[arcsin(nsin a) -a] in PD. When the PB is held in the frontal position the deviation (Vf) takes place at the first and second refracting surfaces and is given by 100Tan{arcsin [nsin{a -arcsin ({sin a}/n)}]}. The difference (D) between Vp and Vf was used to determine the theoretical differences for deviations from 2 to 45 PD.

Figure 2 shows the difference (D) between the measurements obtained in the frontal and Prentice positions (ordinate) against the measurements obtained in the frontal position (abscissa). Two plots are shown, one for the theoretical difference (Vf-Vp in PD) and the other for the observed data.

Two best-fit equations (by least squares), linear in the logarithms of the two quantities was fitted for the calculated and observed data. These corresponded to a power relation between the two variables of the form $ED = aF^b$, where a and b are constants determined by the method of least squares, F being the

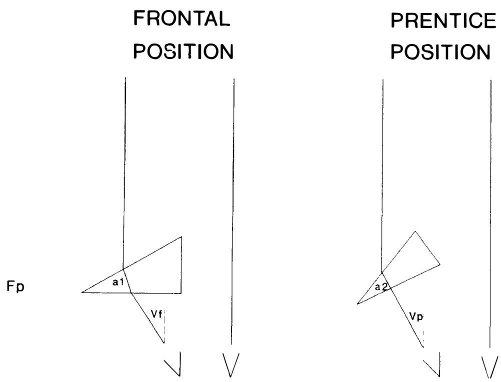

Fig. 1. *The prism in the frontal and Prentice positions. Fp = frontal plane. (Vf = Vp, a1>a2).*

value in the frontal plane. ED represents the difference between the frontal and Prentice positions for a given frontal value. For the theoretical data

$$ED[T] = 0.0003246F^{2.734} \ldots\text{Equation 1}$$

with a correlation coefficient between the log values of r = 0.998. That for the observed data

$$ED[O] = 0.02848147F^{1.536} \ldots\text{Equation II}$$

with a correlation coefficient between the log values of r = 0.933. The correlation coefficient for the theoretical relationship is not a true correlation between two random variables but is rather an indicator of how good the linear approximation is to the theoretical relationship. However, for the observed data the logarithmic difference is a random variable and the correlation coefficient is meaningful in a more usual sense.

The 95 per cent confidence limits were calculated for the mean difference between the Prentice and frontal position values. There was no significant difference between the theoretical values and those obtained from the observed data for frontal values greater than 20 PD ($p>0.05$).

However the differences were statistically significant for the lower frontal values (less than 20 PD), although they are insignificant in practice, i.e. less than 1 PD. This disparity may be caused by the variable displacement of the PB from the eye, which may result in an error in the difference between the frontal and Prentice positions. Although small this error is nevertheless proportionally greater with lower deviations.

For example, in the Prentice position the measured deviation increases as the PB is displaced from the eye by the relation

$$V_2 = V_1 + \text{Arctan } d\text{Sin}V_1/y\text{-}d\text{Cos}V_1.$$

V_1 and V_2 represent the angle of the deviation in degrees for the original and displaced prism positions. d is the distance in mm between the two prism positions and y the distance in mm between the object and the original prism position.

V_2 may approach one or two PD for deviations greater than 35 PD when the target is held at $\frac{1}{3}$rd metre, and the PB displaced 10 mm (Fig. 3).

The measured deviation for the frontal position increases in a similar way.

Discussion

The PCT is based on Duane's parallax test,[3] combining the alternating cover test with the prismatic correction of the deviation. The prism should be used in the Prentice position, with the base of the prism facing away from the direction of the deviating eye.[3] The posterior plane surface of the prism should be normal to the direction of gaze of the deviating eye. The measurements are not truly accurate since the prism should be placed at the centre of rotation of the eye. This inaccuracy can be reduced by placing the object of

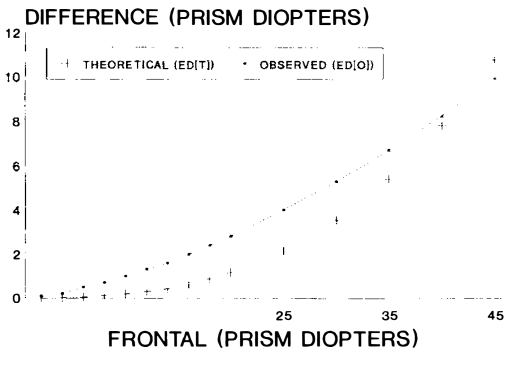

Fig. 2. *The difference (D) in prism diopters between the frontal and Prentice positions, as a function of prismatic deviation measured by a prism held in the frontal position.*

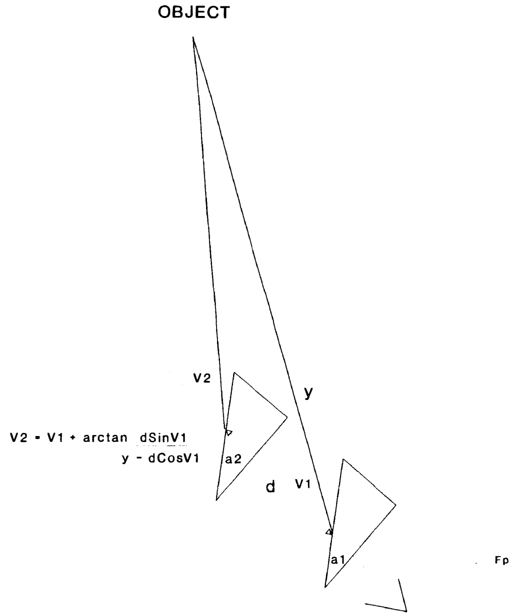

Fig. 3. *Displacement of a prism in the Prentice position. The error introduced into (d) by the displaced prism bar requiring a larger refracting angle (a2) is clinically unimportant (less than 0.03 mm for a2 = 30 degrees). Fp = frontal plane.*

fixation at a far distance from the subject, and holding the prism as close to the eye as possible.

Difficulties may arise in determining the line of fixation of the eye, specially with large deviations and when horizontal and vertical deviations co-exist. This leads to problems holding the posterior surface of the prism normal to the line of fixation, so introducing further errors. As a result of this difficulty, most orthoptists and clinicians use the PB in the frontal position (Fig. 1). Loose prisms however allow simultaneous correction of horizontal and vertical deviations.

This study has shown that, when a PB calibrated for use in the Prentice position is used in the frontal position the observed difference in the measurements obtained between the frontal and Prentice positions increases with the deviation. This is in agreement with the calculated theoretical difference. The percentage coefficient of variation in this study was less than 26 per cent, and less than 14 per cent for values greater than 14 PD in the frontal position. This implies that any change in the deviation during the test, and other factors such as inter-examiner error were small.

As stated above the validity of the PCT assumes a prism to be held at the centre of rotation of the eye. Since this position is not possible the PB is usually held a short distance in front of the eye. This results in an error in one direction which furthermore may vary between the frontal and Prentice positions. Theoretical calculations do not take this into account, which may explain the difference between the calculated and observed data. In the frontal position the distance the PB is held from the centre of rotation of the eye is constant for a given subject. In the Prentice position this distance may vary as the supraorbital margin is not used as a reference. The error resulting from angulating the PB about its vertical axis in the Prentice position occurs in two directions and may be expected to cancel out on repeated testing. Single measurements, however, may incorporate this error. This becomes important when assessing the alignment prior to strabismus surgery, or quantifying a change in the deviation with time. In view of these findings the frontal position is the more reliable and therefore to be preferred.

Unexpected results may arise from the use of the PB in a position for which it is not calibrated. This has implications on functional and cosmetic results and becomes of practical importance with deviations greater than 20 PD. That is a deviation of 25 PD in the frontal position is equivalent to 21 PD measured in the Prentice position (using the equation to fit the observed data).

The variable use of the PB will also result in inconsistent measurements when monitoring a change in the deviation with time. This is of

Table II. *Correction values in PD for measurements in the frontal position.*

Frontal	*Difference*
20	3
25	4
30	5
35	7
40	8
45	10

importance when attempting to monitor a patient's progress, and deciding on the optimal time for surgery.

If a Prentice position calibrated PB is used in the preferred frontal position to measure a deviation greater than 20 PD we would recommend that the difference be read from Table II and subtracted from the measurement obtained in the frontal position, to give the appropriate value corresponding to the Prentice position. These values have been derived from equation (II) and have the advantage of reducing errors in technique. This allows for a more reliable correction to be made.

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References

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