THE CONVERGENCE INDEX AS A MEASURE OF THE CONVERGING POWER.

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Two methods of determining the converging power are in general use. One consists in determining the ability to overcome prisms, base out, thus measuring what is usually called the adduction, but is more properly termed the prism-convergence; the other consists in determining the convergence near-point.*

The prism convergence furnishes at best only an approximate indication of the real converging power. As is well known, the ability to overcome prisms, base out, varies extremely, the variations evidently not representing real differences in converging power but differences simply in knack, *i. e.*, aptitude in learning to perform an unaccustomed act. So we find some who at the start can overcome but 12Δ or 15Δ prism, base out, and who only after repeated trials can do more, and we find others who pass at once from these lower to the higher degrees. Yet, as other tests show, the two have equal and evidently normal converging power. It is only when the patient, after repeated trials, cannot overcome more than a certain comparatively weak prism, and particularly when, even if he does pass from one number to the next higher, he can maintain fusion with the latter but momentarily, that we can predicate from this test a low converging power. In such cases alone the prism convergence really becomes of value as a measure of the convergence,

*The converging power may also be determined with the amblyoscope or stereoscope, but these tests are not in common use for this purpose.

since it then really indicates the maximum of converging power then attainable. In the other cases it indicates much less than the true maximum.

Moreover, when strong prisms are used for measuring the convergence, the measurement is made uncertain by the fact that slight variations in the position of the prisms

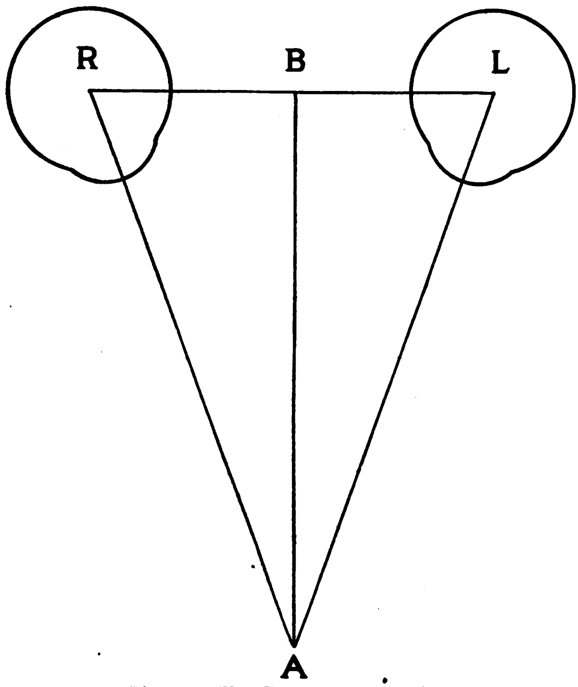

Fig. 1.—The Convergence Index.

A being the convergence near point, and R L the base line connecting the centres of rotation of the two eyes, the convergence index $= \frac{RB}{AB} \times 100$.

cause quite an appreciable change in their deflecting power, so that errors of 5° or 6° in the actual degree of convergence may thus be caused.

The determination of the convergence near-point (Pc) remains as our most reliable means of determining the actual converging power. It is often measured from the cornea, but should properly be measured from the baseline connecting the centers of rotation of the two eyes. We should be careful in any case to indicate from what point the measurement is made. We may conveniently use the symbol PcC if the measurement is from the cornea and PcB if it is made from the baseline. In Fig. 1, AB denotes PcB. This distance (PcB) can be quite precisely measured as follows: The patient's correcting glass, or in lieu of these a trial frame or spectacle frame placed on the patient's nose, is used as a reference plane, which is adjusted so as to be just 11.5 mm.* in front of the corneal apex when the eyes are directed straight ahead. The apex of a millimeter rule is placed against the point where the reference plane crosses the nose, and the rule itself is held perpendicular to the plane, so as to lie strictly in the midline. Along this the test object, which may consist of a pin, with white head two mm. in diameter, or a minute dot on a card, is carried straight toward the patient's nose, the patient all the time being exhorted to converge on it as sharply as he can. The moment the object doubles insuperably, or the moment one of the patient's eyes is seen to diverge, the distance of the object from the reference plane is measured. This distance plus 25 mm. will equal the distance (PcB) of the convergence near-point from the intercentral baseline.

When the patient has considerable vertical deviation, his converging power tested in this way may appear to be poor, when really it is quite good. For, when the test object is brought toward the eyes, he sees two images which he cannot bring together because they are on different levels. As he cannot unite them he makes no attempt to converge. In that case the dot used as the test object should be replaced by a vertical line. The patient will converge on this, because when he does so the two images will unite, even if on different levels, since the bottom of one will join with the top of the other. On such an object a patient will

*10.5 mm. if the eye is quite myopic; 12.5 mm. if the eye is highly hyperopic.

be able to converge sharply, even when for the dot he had apparently very little converging power.

This *convergence distance* (PcB) may be used itself as an approximate measure of the converging power. As such it may be indicated either in millimeters or in meter angles. In the latter case $MA = \frac{1000}{PcB}$ where MA is the number of meter angles and PcB is given in millimeters. But the convergence varies not only with the convergence distance (PcB) but also with the interpupillary distance (Pd), for the greater the latter the greater obviously the work the patient has to do in converging.

In fact, the true measure of the converging power is given by the fraction $\frac{RB}{AB} = \frac{\frac{1}{2}Pd}{PcB}$. This equals evidently the tangent of half the angle of convergence, RAL = C. I propose for this ratio, or rather this ratio multiplied by 100, the name *convergence index* (Ci). We have therefore:

$$Ci = \frac{\frac{1}{2} \text{ interpupillary distance} \times 100}{PcB}$$

A large number of measurements show that the convergence index usually ranges from 35 to 50. If it falls below 35 the patient has a low converging power, and if it persistently falls below 30 he has an actual convergence insufficiency. In many cases it reaches 55, and at times 60. The highest value that I have met with is 63. Now computation shows that the following rather remarkable and very convenient relation between the convergence index and the actual convergence in degrees of arc, in other words between Ci and C, obtains:

Ci	C
5 to 6	Ci + 1°
7 to 13	Ci + 2°
14 to 58	Ci + 3°
59 to 63	Ci + 2°
64 to 68	Ci + 1°
69 to 71	Ci
72 to 74	Ci — 1°

As an index of 14 means a convergence near-point distant 21 to 22 cm. (8 or 9 inches), and as an index above 58 is rarely met with, we say:

For all values of the converging power ordinarily met with, both in normal and abnormal cases, the actual converging power in degrees equals the convergence index plus 3°.

A simple case will illustrate the application of this rule. In a given patient we find a Pd of 60 mm. and the PcB is 75 mm.

$$Ci = \frac{30 \times 100}{75} = 40$$

Hence the actual degree of convergence (C) is 43°.

Even for higher or lower degrees of converging power the error in applying the rule is practically negligible. Thus, if a patient has a Pd of 62 mm. and a PcB of 300 mm. (about a foot)—an extreme case—the angle C reckoned by the rule would be 13°, whereas its true value is 12°; or a discrepancy of but one degree. So, too, if the patient with a Pd of 60 mm. converged down to a point 45 mm. from the base line—also an extreme case—the value of C reckoned by the rule would be 69°, whereas the true value would be 67°. With a convergence so extraordinary, a difference of 2° is of no importance. But in the rare cases where Ci is above 60, it is best to use the table above given.

The rule above given is also obviously useful when we wish to determine the actual angle of convergence made by the visual lines when the patient is regarding an object at any rather near point whether this is his actual near point of convergence or not. When he is so converging, the angle of convergence C^1 is to all intents and purposes given by the relation:

$$C^1 = \frac{\frac{1}{2}\text{ interpupillary distance} \times 100}{D} + 3°$$

where D = distance (from the intercentral baseline) of the object in millimeters.

We may make the statement perfectly general and also perfectly accurate by putting it as follows:

If an object is at a distance D from the intercentral base line, and we denote by Ci′ the fraction

$$\frac{\frac{1}{2}\text{ interpupillary distance} \times 100}{D}$$

and by C′ the angle of convergence of the visual lines, then

$C' = Ci' + 3°$ if D is between 5 and 22 cm.
$C' = Ci' + 2°$ if D is between 22 and 50 cm.
$C' = Ci' + 1°$ if D is between 50 and 100 cm.
$C' = Ci' + 1°$ if D is between 50 and 100 cm.
$C' = Ci'$ if D is over 100 cm.

Ci′ in this case may be called the *relative* convergence index, inasmuch as it corresponds to a point upon which the eyes are converged when not using their maximum converging power. When the eyes are converging to the maximum, so that D represents the distance (PcB) of the real near point of convergence, the convergence index may be called *absolute*.

Since the convergence index by the simple relation indicated gives us the converging angle, it may be said to measure quite directly the *power* of convergence. It has been objected, however, that after all what we wish to know is, not so much the power as the *availability* of convergence. In other words, we wish to know, not how great the angle C is, but how close the near point A is. The closeness of the latter, in fact, measures the usefulness of the converging power for the patient, just as the closeness of the near point of accommodation measures the usefulness of the accommodation in enabling the patient to read. But there is a considerable difference between the two cases. Two persons with the same range of accommodation may have near points differing widely, insomuch that one of the two can read with the utmost ease and the other cannot read at all. But if one person has the same convergence index as another he cannot have an essentially different convergence near point. In fact, for any ordinary value of the index, the variations in the position of the convergence near point cannot possibly amount to more than 2 cm.,* and are usually much less, so long as the index remains the same. Even when the index is low, and the near point of convergence consequently remote, the discrepancies in the position of the latter, although now somewhat greater, are still relatively small and in no case so great as to be of practical importance.

We may say, therefore, that the convergence index is not only a true measure of the converging power, but gives also in all cases a sufficiently accurate notion of the utility of this converging power for the patient—i.e., of its availability in enabling him to look at near objects.

DISCUSSION.

DR. ALEXANDER DUANE, New York: It is hardly worth while to refer to it in an assembly like this where every one knows how to record these things; but I was surprised to find how many oculists are unaware of the true method of measuring the pupillary distance in order to get it right to within a millimeter. This can be done while making the measurement I have described. Direct the patient to cover the left eye and to look with his right into your left. Cover your right eye and sighting with your uncovered left, place the zero of a millimeter scale opposite the center of his right pupil. Then, holding the scale steady, make him open his left eye and cover his right, while you open your right eye and close your left. Sighting with your uncovered right eye you now note what point on the scale is opposite the center of the patient's left pupil. This will give the pupillary distance when the eyes are parallel, and this too whether the patient has a deviation of the eyes or not.

* Thus with a convergence index of 30 (quite the lower limit of normal converging power), the distance of the convergence near point, *i. e.* the PcB, would be 9 cm. if the interpupillary distance was 54 mm. and 11 cm. if the interpupillary distance was 66 cm.

DR. LANCASTER: Will Dr. Duane tell us also how he measures the distance from the cornea to the lens in the trial-frame?

DR. DUANE: I would say that I take this measurement simply by making the patient look straight ahead, while I look at him from the side and read off from a millimeter scale placed against the temple the distance between his cornea and the reference plane. That, of course, is a little rough; and a simple instrument could be devised to enable one to do it with precision. It is, however, accurate enough.

DR. ROBERT S. LAMB, Washington, D. C.: With regard to getting pupillary distance, I would say that I have used a two millimeter pin-hole disk for years. In the trial-frame, or optometer, one pin-hole disk is placed over each eye, and each in turn is covered with a blank disk until the patient can see with each eye the same test object at twenty feet. Later I take the pupillary distance for near work in the same manner, using No. 1 of Jaeger test type.

I find the difference between the pupillary distance for distant vision and near vision sometimes as much as five millimeters. I take the pupillary distance on all patients in that way. The procedure is very useful, and for accuracy in obtaining pupillary distance I have found nothing to equal it.

CURVATURE AND INDEX MYOPIA, WITH REPORT OF CASES.

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Curvature Myopia.—This condition may be due either to an excessive curvature of the cornea or of either surface of the crystalline lens. In a normal eye, curvature myopia rarely exceeds in amount more than one or two diopters, in fact, seldom reaches that amount. When of considerable or large amount it is always associated with pathologic