Chapter 6

ACCOMMODATION AND CONVERGENCE

AC/A RATIO

I. ACCOMMODATION

The process by which the dioptic power of the eye may be altered by changes of convexity of the crystalline lens. Process is accomplished by contraction of the ciliary muscle allows the fibers of the zonules to relax and the lens in the elastic capsule becomes thicker and more relaxed, thus accommodation occurs. The unit used to express the refraction of the eye is the *diopter* (D). It designates the refractive power of the lens which is equal to the reciprocal of the lens focal length in meters. Two *diopter* lenses bring parallel rays of light to focus at ½ m.

The amount of change in the refractive power of the eye brought about by accommodation gradually decreases with age, ranging from about 20 D. in the very young child to 1 D. at approximately age 60. This process called presbyopia usually becomes clinically significant about the age of 40-45 at which time bifocals for near work are usually required.

With respect to the emmetropic eye, light rays emanating from an object point within infinity (20 ft. or 6m. for practical purposes) are divergent on striking the retina thus producing a blurred image. To bring these divergent rays to a point focus coincident with the retina, the dioptric power of the eye must be increased sufficiently by accommodation unless lenses are used. The exact nature of the stimulus by means of which the blurred image on the retina gives rise to the accommodation reflex is not entirely known but the resultant accommodation occurs with great precision and is generally completed in about half a second.

II. CLINICAL MEASUREMENTS OF ACCOMMODATION

A. *Far point* of accommodation-the axial point is conjugate with retina axial point in the un-accommodative eye. It is the most distant point from the eye an object is seen clearly. Example:

1. Far point of the emmetropic eye is at infinity.
2. Far point of the myopic eye is in front of the eye.
3. Far point of the hyperopic eye is a virtual point behind the eye.

B. *Near point* of accommodation (NPA) Nearest point of clear vision-position closest to the eye where a small print can be kept in sharp focus by maximum accommodation.

C. *Amplitude of accommodation* - difference express in diopters (D) between *far* point and *near* point of accommodation.

D. *Measurement* of amplitudes of accommodation. A = F-N

A = is the amplitude of accommodation.

F = the vergence of light rays corresponding to the far point – is the most distant point from the eye an object is seen clearly.

N = the vergence of near point rays at the eye-nearest point letter can be seen.

Clinically is performed separately with each eye.

1. Full correction worn – place Prince rule – outside temporal corner of the eye
2. Small print close to the eye – and moved back until clear – *far point*
3. Nearest point letter can be seen – *near point* (use Prince rule). Binocular reading usually indicates a nearer *NPA*.
4. The size test type to be used should correlate with the patient's corrected visual acuity for distance. If the Prince rule or similar device is used for this test, the near point of accommodation in centimeters, the amplitude of accommodation in diopters, and the normal amplitude of accommodation by age are readily determined. All three scales are marked on the rule.

I. CONVERGENCE

A. *Voluntary convergence* – volitional rotation of the eyes, nasalwards.

This is the only dysjunctive movement of the eyes which can be initiated at will. The exact location of the cortical center for voluntary convergence is not known.

B. *Involuntary convergence* – psycho-optical reflex on fixation and refixation reflexes.

Requires cooperation of the cortex in the act of attention.

Involuntary convergence is divided in four types:

1. *Tonic* – Brings eyes from the usual divergence of rest to parallelism in primary position – Static
2. *Accommodative* – convergence reflex brought forth in response to accommodation to obtain a clear single image
3. *Fusional* convergence brought about in interest of fusion to overcome diplopia – Dynamic
4. *Proximal* – convergence resulting from awareness of a near object – Dynamic, eg. (Synoptophore) – machine convergence

C. *Near* point of convergence – nearest point object is seen clearly.

1. objectively – penlight to nose
2. subjectively – patient sees double
3. red glass and light test

D. *Amplitude* of convergence – Maximum amount of convergence which can be obtained while binocularity is present.

Absolute fusional convergence- amount of convergence which can be exerted irrespective of state of accommodation.

Relative fusional convergence – Amount of convergence which can be exerted while accommodation remains constant.

E. Units used in measurement of convergence.

1. Prism diopter – Δ 1 prism diopter will displace a ray of light 1 cm at 1 meter distant

2. Meter angle (M.A.) – angular use of convergence

One meter angle is the amount of convergence required to binocularity fixation at 1 m away equal to the reciprocal of distance (in meters) between the object and bridge of the nose. Value varies directly with interpupillary distance.

Conversion of M.A. to Δ's – multiply the number of M.A.'s by the interpupillary distance expressed in cm, eg,

1 M.A. = 6^{Δ} with 6 cm PD at 1 M
1/3 M = 6^{Δ} x 3 = 18^{Δ} at 1/3 M

F. *Near* Reflex

When looking at a close object, an innervation to contract is sent simultaneously to ciliary muscle for accommodation, to M R muscle for convergence and sphincter papillae for pupillary constriction to obtain a clear image.

II. AC/A RATIO – ACCOMMODATION RELATIONSHIP

Convergence Relationship is a very tight, linear one

A. For each *impulse* for a change in *accommodation* there is a corresponding impulse for change in convergence.

B. For each individual an *impulse* for a certain amount of *accommodation* reflex brings forth a *precise quantity* of *accommodative convergence* in a *consistent ratio,* which is *peculiar and stable* in the individual relationship - this is termed the AC/A ratio.

$\frac{AC}{A}$ = accommodation convergence in prism diopters or meter angle / accommodation in diopters

AC/A ratio is accommodative convergence in prism diopters associated per diopter of accommodation.

C. Normal AC/A Ratio

Ideally, the quantity of accommodation convergence reflexively associated with that amount of accommodation required for clear vision at any fixation distance would allow exact bifoveal fixation.

However, seldom does this occur. Usually, there is a slight deficit and occasionally an overabundance of accommodative convergence, which must be either augmented or overcome by employing fusional vergences. In cases of a normal AC/A ratio, the fusional amplitudes can usually successfully offset this discrepancy.

The normal AC/A ratio expressed in meter angles of convergence is 1 M.A./1D, i.e., for a fixation distance of 1/3 M. the 3 D of accommodation required for clear vision is reflexively associated with 3 M.A. of convergence, giving a ratio of 1 M.A./1D.

From a clinical standpoint, the deviation of patients with a normal AC/A is found to be nearly equal for distance and near. Normal AC/A ratio is 4-5$^{\Delta}$/1D.

D. Abnormally High AC/A Ratio

In some cases, the amount of accommodative convergence brought forth in response to accommodation is excessively high. These are designated as having high AC/A ratios. Two theories have been postulated regarding these cases:

1. The convergence mechanism is highly responsive to accommodative stimuli.

2. There is a weakness of the accommodation mechanism, which requires excessive innervation to bring about the desired accommodation and this affects an excessive accommodative response. AC/A ratios as high as 10$^{\Delta}$ to 12$^{\Delta}$ have been recorded.

   Clinically, the deviation of patients with an abnormally high AC/A ratio is found to be more esotropic (or less exotropic) as near than at distance; the near deviation approximates the distance deviation when measured with +3.00 D lens OU.

V. MEASUREMENT OF AC/A RATIO

(Absolute Value)

1. Gradient method – $AC/A = \left[\frac{|\Delta_1 - \Delta|}{D}\right]$

Δ = original deviation
Δ_1 = deviation measurement with lens
D = power of lenses

Example:

Δ (original deviation) = esophoria 17

Δ_1 (deviation with +3 lens) = esophoria 2

D lens of 3D $\quad AC/A = \left[\frac{|2-(+17)|}{3}\right] = 5^{\Delta}/1D$

2. Heterophoria method

$$A\ C/A = PD + \left(\frac{\Delta N - \Delta o}{D}\right)$$

PD = pupillary distance (cm)
ΔN= deviation for near
Δo = deviation for 6 m
D = fixation distance

Example:

PD = 6 cm
ΔN = esophoria 17
Δo = esophoria 2
D = 33.3 cm (3D)

$$AC/A = 6 + \left(\frac{(+17) - (+2)}{3}\right) = 6 + \left(\frac{(17-2)}{3}\right) = 11\ D$$

Note: If no difference in D&N measurements – AC/A is the same as PD in cm.

Note: Abnormal high AC/A ratio accommodative convergence brought forth in response to accommodation is excessively high.

Two theories for high AC/A ratio:

(1) Convergence mechanism is highly responsive to accommodation stimuli.
(2) Weakness in accommodation mechanism requires excessive innervation to bring about the desired accommodation.

VI. EXAMPLES

Normal and High AC/A Ratio

ET sc = 16	Rx + 3.00	E = cc = 1
ET' sc = 16		E'= cc = 1

AC/A ratio (gradient)
AC/A ratio (heterophoria) = (PD 50 cm)

Accommodative ET With High AC/A Ratio

E sc = 2	AC/A ratio (gradient)
ET' sc = 23	AC/A ratio (heterophoria) – PD 50 cm

+2.00 E cc = 2

VII. CLINICAL METHOD IN DETERMINING AC/A RATIO

A. Clinical method:

1. If a refractive error is present, it should be fully corrected.
2. Have patient fix a 20/30 target at six meters.
3. Measure the full amount of deviation with the prism and alternate cover tests.
4. Re-measure the deviation with a -1.00 diopter sphere placed in front of both eyes over the correction.
5. The difference in the amount of deviation between the first and second measurement represents the AC/A ratio.