chloroform, and divided the inferior rectus by the subconjunctival operation. There were no lateral expansions of the muscle, and the eye immediately righted itself, turning at first a little outwards; this, however, corrected itself after the first day. The eye is now quite straight, and all deformity is removed. When I last saw him, he had not received his astigmatic glasses, but I have no doubt that, when he gets them, he will not only be greatly improved in appearance, but will enjoy good vision.*

* *Medical Times and Gazette*, vol. i. 1871, p. 243.

CHAPTER XV.

DISORDERS OF REFRACTION AND ACCOMMODATION OF THE EYE.

Myopia—Hypermetropia—Presbyopia—Astigmatism—Asthenopia: motor, and accommodatory.

Disorders of refraction and accommodation,

It is remarkable how few cases of impaired vision, due to anomalies in the refraction or accommodation of the eye, are met with among the lower classes in India. In fact, whole races of people appear to be actually strangers to these diseases. For instance, some years ago I was among the Sonthals, the aborigines of Bengal, dwelling in the Rajahmahal hills, and I took every opportunity of examining the eyes of the people I was brought in contact with, for the purpose of discovering if myopia and such like diseases existed among them; but I never yet saw a young Sonthal whose eyes were not emmetropic; the same remarks apply to nearly the whole of the lower classes in Bengal, with the exception of those living in Calcutta and other large towns, where overwork, sensual indulgence, and a polluted atmosphere have done a vast deal of harm to the physical as well as the moral eyes of the inhabitants.

rarely met with among some classes.

It is an established fact that, for correct vision, rays of light which enter the eye from every point of an object under observation, must be brought to a focus upon the bacillar layer of the retina; it follows, therefore, that the healthy eye possesses an inherent power by means of which both finite and infinite rays are brought to a focus on the retina—that is, both divergent and parallel rays are made to converge to a

Focal adjustment of eye necessary.

point on its bacillar layer.* It is to the anomalies which occasionally exist in the human eye, with regard to its power of effecting these changes, that I would now draw attention. In the remarks I have to make on this subject I assume that the ciliary muscle is the active agent in altering the curvature of the lens. (See page 16.) Beyond the integrity of the ciliary muscle, the eyes require for perfect vision the faultless aid of the recti muscles, so that the posterior poles of each retina may be made to converge accurately on a given spot, and thus produce single vision by the use of two eyes. In an emmetropic eye the act of accommodation and of the convergence of the optic axes become habitually associated, so that it is difficult to exert either of them separately. Thus in looking at a near object, as in reading, the ciliary muscle contracts so as to increase the convexity of the lens, and at the same time the internal recti converge the eyes upon the letters of the book; in the normal eye the forces thus brought into play are perfectly adjusted and governed by branches of the third nerve: but in the hypermetropic eye, and also among persons suffering from myopia, there is a disturbance in the co-ordination of the converging and accommodating muscles of the eye, and hence under these circumstances the sense of fatigue which follows the long-continued use of the eyes.

Snellen's test types;

As I have before mentioned, Dr. Snellen's test types are those usually employed in determining the acuteness of vision. Some of these types are to be found at the end of this volume, and it may be useful to refer to the following rules laid down by Dr. Snellen in reference to their use:—

rules for their use.

I. The smallest angle, at which objects of known size and form can be distinguished, determines the degree of the relative acuteness of vision.

II. To determine the smallest visual angle, we measure the utmost distance at which objects of definite size can be recognised.

III. A visual angle and corresponding distance being

* Finite rays are those proceeding from objects within sixteen feet of the eye, they are divergent rays, and their divergency increases in proportion to the proximity of the object under observation to the eye. Rays from a point situated beyond six feet from the eye are considered as being parallel to one another, and are called infinite rays.

taken as the unit of measure, the proportion between such distance and that at which the object is actually seen, expresses the acuteness of vision.

IV. We take as unit for comparison the recognition of letters seen at an angle of five minutes.

V. The numbers placed above each type express in Parisian feet the distance at which the letters are seen at our standard angle of five minutes.

VI. The utmost distance at which the types are recognised (d), divided by the distance at which they appear at an angle of five minutes (D), gives the formula for the acuteness of vision (v).

$$v = \frac{d}{D}$$

Thus if d and D be found equal, No. XII. of the test types being recognised at a distance of 12 ft. $v = \frac{12}{12} = 1$; in other words, there is normal acuteness of vision. If, on the other hand, d be less than D, and if No. XII. be only visible within 6 ft. or VI. within 2 ft. or No. XXX. at 20 ft.

$$v = \frac{6}{12} = \frac{1}{2}$$
$$v = \frac{2}{6} = \frac{1}{3}$$
$$v = \frac{20}{30} = \frac{2}{3}$$

but d may sometimes be greater than D, and No. XII. be visible at a greater distance than 12 ft.; in this case the acuteness of vision is greater than the normal average.

VII. The normal acuteness of vision decreases with age (see Presbyopia).

VIII. The value of v should be found equal in testing with the different types, each at its corresponding distance. If such is not the case, and v appears to diminish considerably within or beyond a certain distance, it may be inferred that the refraction is at fault, or that the eye is not adjusted for such distance.

Selection of glasses.

With regard to the form of glasses to be used by patients suffering from myopia, or, in fact, from any disease of the eye requiring them, spectacles are far the best. They should be made to fit so that the glasses may be parallel with the patient's irides, and they should be placed as near the eye as possible, without allowing the cilia to brush against them when the lids are closed, except in cases of presbyopia, as I shall subsequently explain. The glasses with a spring fitting over the nose are generally objection-

able for prolonged work, because the patient is apt to clap them on carelessly, sometimes close to the eyes, and at other times on the tip of the nose; moreover, they are frequently worn anything but parallel with the irides. An eyeglass is still more objectionable than the spring spectacles; binocular vision is ignored, and one eye only being used, the other may take to squinting outward.

With reference to lenses, the sign − before a fraction signifies that the number indicated is a concave lens (negative focus); thus if we write $-\frac{1}{8}$ we mean concave lenses of eight-inch focal power. The sign + (positive focus) before a fraction signifies that the lens mentioned is a convex one; $+\frac{1}{12}$ means a number 12 convex lens, or of twelve-inch focal power. The figure ⊃ is the sign of combination, as in the case of a spherico-cylindrical lens.

We make use of certain abbreviations in describing cases of faulty accommodation and refraction, such as C. M. corneal meridian; M. for myopia; Hm. hypermetropia; C. cylindrical glasses; S. spherical glasses. For example, a patient without glasses V. $\frac{20}{80}$ left eye, with $+\frac{1}{40}$ C. V. $=\frac{20}{20}$, and with $(+\frac{1}{40}$ S. ⊃ $+\frac{1}{40}$ C.) reads fluently and without strain No. 2 S″, which means that without glasses the patient could read No. 80 of Snellen's test types with the left eye, at 20 feet; with convex cylindrical glasses* of 40-inch focal power, he could read No. 20 of Snellen's test types at 20 feet distance, and with a combination of number convex 40 spherical,† and convex 40 cylindrical lens he can read No. 2 of Snellen's test types at ordinary distance.*

* A cylindrical lens is the segment of a cylinder, and refracts rays of light most in a plane at right angles to the axis of the cylinder of which it is a segment, whilst those rays of light which strike it in the plane of the axis, undergo no refraction whatever. For the sake of simplicity we may therefore restrict our consideration to these two directions—that of the axis and that of the transverse diameter. A 6-inch convex cylindrical lens means one which refracts a pencil of parallel rays thus: (1), those which strike it parallel to the transverse diameter of the cylinder are focussed at six inches from the surface of the lens; (2), those which strike it parallel to the axis of the cylinder are not focussed at all by the lens, but pass through it refracted not more than they would have been by passing through a piece of plain glass.

† A spherical lens is a segment of a sphere, and refracts the incident rays of light equally in all planes of the segment, so that spherical lenses are bounded by a spherical surface on one or both sides, they have the power of changing the direction of parallel rays of light passing through them, so that they cause the rays in the case of convex lenses to converge to a given point—the principal focus—or *the focus* as it is commonly called; or in the case of concave lenses, parallel rays of light diverge after passing through the lens, as if they proceeded from the principal focus.

EMMETROPIA. EMMETROPIA.—By Emmetropia is meant the normal condition of the eye as regards its visual range. In this case, parallel rays of light are brought to a focus on the retina when the eye is at rest, and by a voluntary action of accommodation, divergent rays are also focussed on the bacillary layer of the retina; so that objects at all ordinary distances can be clearly and distinctly perceived, while the nearest point for distinct vision is at about four inches from the cornea. As a test of this condition, Snellen's types may be clearly deciphered at the respective distances assigned to them; and after the instillation of atropine, so as to paralyse the ciliary muscle, we find that the patient's long sight is hardly affected at all. I need hardly repeat that in the normal eye, the lens is passive when examining objects at a distance, consequently paralysis of the ciliary muscle only slightly affects the far point. Vision of distant objects is not improved either by convex or concave spectacles. The emmetropic eye can clearly define letters of small type at a distance of exactly 10 inches from a convex 10″ lens placed before the eye; for rays of light from the print fall under these circumstances as parallel rays on the eye.

Range of accommodation in health.

MYOPIA. MYOPIA.—In Myopia, or short-sightedness, parallel rays of light are brought to a focus anterior to the retina, divergent rays alone being focussed on the retina. This condition may be induced by increased refractive power of the dioptric media, or more com-

Near objects alone distinct.

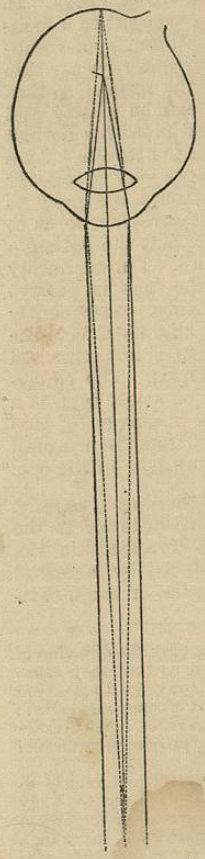
* Works treating of ophthalmic subjects were formerly so encumbered with long words, that few people cared to study them; a reaction has however set in, several distinguished oculists have taken to describing their ophthalmic cases in a form of shorthand writing, which must unfortunately render their work absolutely incomprehensible, unless to those who had previously studied the characters employed by these authors.

monly by elongation of the eyeball in the antero-posterior axis.

Congenital or acquired.

Myopia is often congenital, but may arise from over-exerting the eyes upon minute objects, or by straining them in consequence of defective vision caused by opacities in the dioptric media. (See page 275.) Under these circumstances the accommodation of the eye is so much exercised, that in the course of time the lens assumes a permanently increased convexity, its refractive power is augmented, and myopia is the result. Whenever myopia is established, unless corrected by proper glasses, long-continued work induces hyperæmia and congestion of the internal tissues of the eye, especially of the choroid; and among those predisposed to suffer from a posterior staphyloma the disease is very apt to increase rapidly (page 378), a bulging of the sclerotic takes place posteriorly, so that the antero-posterior axis of the eye becomes elongated, and the rays of light are brought to a focus anterior to the retina. It is not that the point of intersection of the rays of light passing through the lens is in an abnormal position in this case, but the layer of rods and bulbs, is protruded backwards, so that the rays impinging on it form a dispersed circle of light (Fig. 50).

FIG. 50.



Production of post. staphyloma,

Posterior staphyloma is thus common among myopics; in fact, Von Graefe states that as a general rule, if a patient's far point does not exceed five inches, the myopia is due to that disease; and there can be no doubt that by far the greater number of

a common cause of myopia.

cases of short-sightedness we meet with arise from this cause. As I have already described the phenomena, progress, and probable termination of posterior staphyloma, there is no necessity for my entering on a further examination of this cause of myopia. One cannot, however, too strongly impress on patients who may be suffering from that affection, the necessity of avoiding overworking their eyes, particularly in the stooping or lying posture; if they persist in this, it is evident that there is a constant strain on the eyes to keep up the necessary strong convergence of the eyes on a near object, and in addition the accommodative effort is considerable, so that the excessive forces thus called into play must produce congestion of the choroid, and with it an increase of the posterior staphyloma, or it may set up incurable disease in the vitreous or other tunics of the eye. Nor should such patients be allowed to read with the book or paper too close to them, for the posterior staphyloma is probably induced by the condition known as insufficiency of the internal rectus, in which an undue amount of pressure is exerted on the globe, during convergence of the optic axes, by the action of the obliqui; this tends directly to produce distortion of the globe, and augment the degenerative changes going on in the choroid (p. 376).

Preventive measures.

Diagnosis.—It would appear almost unnecessary to remark that when a patient consults us for shortness of sight, we should in the first instance ascertain if the case be one of simple myopia, or of some other form of disease inducing symptoms of a somewhat similar nature; nevertheless, mistakes too often arise through neglecting to make these necessary inquiries.

Diagnosis.

Myopia is characterized by objects at the near point of vision being distinctly seen, whereas those at a distance are very indistinct; but on placing a suitable pair of concave glasses before the myope's eyes, he at once defines distant objects with perfect accuracy, provided there be no impairment of vision in addition to the myopia. On the other hand, if the apparent shortness of sight arise from other causes, near objects will generally appear dim, and the far sight will certainly not be improved by concave glasses.

Effect of glasses.

The physiognomy of many myopes is peculiar; they are in the habit of almost closing their eyelids in

Physiognomy.

distant vision; by so doing they cut off a number of the rays entering the pupil, and thus diminish the circles of diffused light which form on the retina (Fig. 50).

Cornea seldom very convex.

It is an error to suppose that as a general rule those suffering from myopia have prominent corneæ. Donders states that the reverse of this is usually the case, though no doubt conical cornea may give rise to short-sightedness.

The ophthalmoscope as a test.

If the eye of a person suffering from myopia be examined with the ophthalmoscope (the direct method of examination being employed), in consequence of the augmented refractive power which exists in the dioptric media, or the lengthening of the eye which is equivalent to it, and which is in fact the cause of the disorder, the rays of light converge immediately after emerging from the cornea; they cannot, therefore, be brought to a focus on the observer's retina, so as to present a clear erect image, however near his eye be approximated to that of the patient; it is only when diverging, after intersection, that they are fitted to produce distinct vision, the image being necessarily an inverted one. In a myopic eye an erect image cannot be seen by the direct method of examination, unless a concave lens be interposed between the eye and the ophthalmoscope; but at a distance of some fourteen inches an inverted image will be distinctly visible without a lens. That the image is an inverted one, may be proved by the observer moving his head either to the right hand or the left, when the object under examination will appear to move in a precisely opposite direction.

No erect image seen;

but an inverted one without a lens.

If, therefore, on examining a person's eye by the direct method, a clear, enlarged, and inverted figure of the retina be seen at a distance of fourteen or fifteen inches from the eye, it may with safety be affirmed that the individual is myopic; and this diagnosis will be confirmed, if it be found impossible to see an erect image, however close the ophthalmoscope be brought to the patient's eye.

Diagnosis. By test types.

If the myopia does not exceed $\frac{1}{24}$, the patient will be able to read Nos. 1 and 2 of Snellen's test types at one and two feet from the eyes; but he will be unable to see clearly beyond twenty-four inches, and hence cannot make out the larger test types at the distances indicated by the figures placed above them. If the

degree of myopia be higher than $\frac{1}{12}$, then No. 1 of S. will not be read at one foot, and the furthest distance at which the types can be distinctly read will indicate the probable degree of the myopia.*

To determine the degree of myopia,

To Determine the Degree of Myopia.—The system adopted in examining recruits for the army is certainly, as Professor Longmore remarks, one of the most easily applied means of determining the degree of myopia. One eye must be examined at a time; the other being closed, or still better screened from the light. Our object is to discover the excess of the refracting power of the eye under examination, as compared with an emmetropic eye. In describing emmetropia, I mentioned the fact that with a + 10″ lens placed before the eye, it would be able to read small type at 10″ from the lens, for under these circumstances the light coming from the print would fall as parallel rays on the eye. But if this same + 10″ lens is placed in front of an eye affected with myopia, evidently in consequence of its excessive power of refraction, the eye will be unable to define the print at 10″; but let us suppose that by bringing the print to a distance of 6″ from the lens the letters can be clearly seen; the difference between a + $\frac{1}{6}$ and a + $\frac{1}{10}$ lens is the measure of the excess of the refracting power of this eye:—

find excess of refraction with a convex lens.

$$\therefore M = \tfrac{1}{6} - \tfrac{1}{10} = \tfrac{1}{15},$$

and a 15″ concave lens will neutralize the + $\frac{1}{15}$ of excess of refractive power in this particular instance. Another method of determining the degree of myopia is as follows:—It is first necessary to ascertain what is the furthest distance at which the patient can read No. 1 of Snellen's test types; in fact to determine the distance of his "far point." Suppose he can clearly define No. 1 up to ten inches from the eye; this being his far point, he will require a concave lens of ten-inch focal length, which, by the dispersive power it possesses, will counteract the excessive refractive power of his eye, enabling him to bring parallel rays to a focus on

Determination of the focal length.

* "Manual of Instructions for Guidance of Army Surgeons in Testing the Range and Quality of Vision." Second Edition, p. 16. By Surgeon-General T. Longmore, C.B., Professor of Military Surgery, Netley School.

his retina, and thus correct the existing myopia. No. 10 concave glasses would, however, under these circumstances, be too strong, because the convergence of the optic axes at ten inches is such as to prevent the eye exactly accommodating itself for distant objects with parallel optic axes; consequently 10 is not precisely the power best adapted to the case, and this may be ascertained by first placing a concave and then a convex glass before the lens; should the former improve the sight, 10 will not be sufficiently powerful to neutralize the myopia; if, on the other hand, a convex lens improve the sight, 10 is too strong a glass, and we must try a weaker one; but should neither concave nor convex glasses improve the sight, we may depend upon this being the power necessary to correct the existing myopia. As a rule, the weakest glasses which neutralize the myopia may be given.

Illustration.

Supposing a person suffering from myopia which is overcome by $-\frac{1}{12}$ lens for distant objects, and he requires glasses to enable him to see music or print at 24′, we shall be able to discover the necessary glasses as follows: $-\frac{1}{12}+\frac{1}{24}=-\frac{1}{24}$: hence a -24 lens will render objects clear at 24″.

Myopia measured by ophthalmoscope.

Lastly, we may form an approximate idea of the degree of M. by means of the ophthalmoscope; for, as I have already explained, we can get an erect image of the fundus of a myopic eye, if we place the ophthalmoscope very close up to the patient's eye; but to obtain an erect image beyond the point at which the converging rays cross, we must fix a concave lens behind the sight-hole of the instrument; and the strength of this correcting lens will enable us to form an idea of the degree of myopia from which the patient is suffering; *provided that in making the examination we can ignore the fact that we are looking at a near object, and use no accommodative effort*, so as to allow parallel rays of light to be focussed on our retina. The reason of this is, that if we advance the ophthalmoscope sufficiently near to the myopic eye, we shall receive from it converging rays which will form an erect image on our retina. But beyond the point at which these converging rays cross one another an inverted image would be focussed on our retina, unless the converging rays are rendered parallel by means of a concave lens placed in front of our own emmetropic eye.

Accommodation must be suppressed.

The weakest concave lens, therefore, which renders these converging rays parallel, so as to enable us without any accommodative effort to observe an erect image of the patient's retina, will give us an idea of the existing myopia.

Choice of glasses

Choice of Glasses.—In selecting glasses for a patient suffering from M., we must examine first one eye and then the other; if we find that the refractive power of the eyes differs, we should order glasses which will neutralize the defect in the eye which suffers least from myopia; it is not advisable under these circumstances to attempt to overcome the faulty sight in both eyes by supplying the patient with spectacles the lens on one side being stronger than that on the other side. For instance, a patient comes to us affected with M.: we place him twenty feet in front of Snellen's test types from No. CC. to XX., and find that he cannot define any of the letters; we then direct him to walk slowly up towards the test types, and discover that he can see No. XX. at 10′ from the test object with the right eye, but he can only see the same type at 9′ distance with the left eye; our object will be to supply him with glasses which will neutralize the excessive refraction of the right eye, and this may be done by means of a + 10″ lens, or by measuring the furthest point at which he can read No. 1 type, as above described; having by either one or both these methods found out the concave glass which neutralizes the existing M. in the right eye, he should with this lens be able to decipher clearly the letters from No. CC. downwards, at the respective distances at which they can be defined by an emmetropic eye.

for least affected eye.

Example.

Hypermetropia

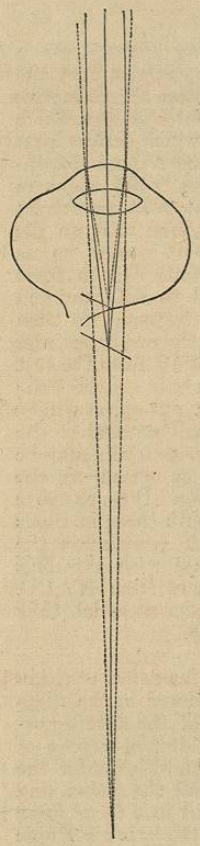
Hypermetropia.—Hypermetropia is a defect of vision depending on a want of refractive power in the dioptric media, or else on a shortening of the antero-posterior axis of the eyeball, so that, during repose of accommodation, parallel rays of light which enter the eye, converge towards a point behind the retina, and convergent rays alone can be brought to a focus upon the retina. The consequence is, that the hypermetropic eye is obliged to exert its accommodating power to bring rays even from distant objects (parallel rays) to a focus on the bacillar layer; and for near objects

Rays converge to a point behind retina.

(divergent rays) this effort has to be considerably increased, so that both the far and near points of vision are disturbed (see Fig. 51).

Often no marked symptoms.

FIG. 51.



Hypermetropia (H.), like myopia, is often an hereditary affection, and exists therefore in several members of the same family. H. may not be attended by any very striking symptoms; the patient's sight is imperfect, but by an effort of accommodation he can generally so far overcome the defect as to be able to perform all ordinary work; but the hypermetropic eye cannot quickly adjust itself for far objects, as in shooting. Sooner or later, however, symptoms of *asthenopia* supervene, the words which a person suffering from hypermetropia happens to be either reading or writing appearing to run into one another, becoming very indistinct; distant objects are also confused, so that in fact the patient's sight becomes exceedingly defective: nevertheless it may be good enough to define large objects, and even small ones in a clear light and for a short time. We can hardly be too cautious in attending to the complaints of children when suffering from what are often called weak eyes, for in very many such instances the real cause of the defective vision is hypermetropia, and the inability of the child to define letters induces asthenopia and a congested and painful condition of the choroid and even of the conjunctiva.

Asthenopia in time.

From straining of accommodation.

The immediate cause of this state of things must be sought in the straining to which the accommodatory mechanism of the hypermetropic eye is exposed, in order to increase the convexity of the anterior surface of the lens, so as to compensate its deficiency of refracting power, and to correct, in some measure, the hypermetropia. After a time the patient can no longer maintain the accommodatory effort which is necessary for this purpose, and hence the symptoms above noticed (asthenopia).

Congenital.

Hypermetropia may arise from congenital malformation of the eyeball, its antero-posterior axis being shortened; or the same result may follow from *aphakia*, that is, absence of the crystalline lens. Under these circumstances, we can readily understand that rays of light passing through the dioptric media cannot be brought to a focus on the retina, unless, indeed, the focal distance be shortened by means of a convex lens held in front of the eye. H. sometimes appears when persons have reached about fifty years of age, it comes on with presbyopia, and seems to be due to senile degeneration: this form of H. has been designated as *acquired* H., to distinguish it from *original* H. due to congenital defects in the formation of the eyeball.

Complicated with strabismus.

It is by no means an uncommon circumstance to meet with cases of hypermetropia complicated with strabismus; this is explained by the fact, that when a person is using his eyes for near vision (divergent rays) the action of the internal recti in causing the optic axes to converge upon the object under examination, is accompanied by a corresponding automatic action of the ciliary muscle, to produce the requisite amount of accommodation. In hypermetropia the convergence no longer corresponds with the accommodation required; but the hypermetropic patient unconsciously avails himself of this natural association of movements, and assists the sustained action of the ciliary muscle, which is necessary for distinct vision, by an extraordinary exertion of the internal recti.* But, as Pro-

Accommodation aided by convergence.

* "There exists a certain connexion between accommodation and convergence of the visual lines; the more strongly we converge, the more powerfully can we bring our faculty of accommodation into action. A certain tendency to increased convergence, so soon as a person wishes to put his power of accommodation upon the stretch, is therefore unavoidable."—"On the Anomalies of Accommodation and Refraction of the Eye," by F. C. Donders: translated by W. D. Moore, p. 294, 1864.

fessor Longmore remarks in the case of a person suffering from H., the patient can only accommodate his vision to a point beyond the intersection of the visual axes, and consequently double vision would result, if both eyes were equally directed towards a near object. One eye therefore becomes the working eye; the other, in order to overcome the inconvenience of diplopia, deviates from its natural position, so that the rays of light from the object under observation fall on the outer or less sensitive part of the retina, and are ignored by the patient, the constant disproportionate action of the internal recti for these purposes becomes habitual and leads to acquired strabismus.* As the strabismus becomes more confirmed, the functions of the retina grow weaker, and at length may be completely destroyed.

Tenotomy and glasses required.

In the earlier stages of the disease, when the strabismus is intermittent, it may be corrected by the use of convex glasses to neutralize the hypermetropia, but in the majority of cases it is necessary to divide the internal rectus; this operation should be performed as soon as possible, for otherwise the sight of the squinting eye may become materially impaired; the image formed upon it being ignored by the sensorium, and the nervous apparatus not being exercised, atrophy of the retina ultimately ensues. After tenotomy, it is absolutely necessary that the patient should be supplied with glasses to neutralize the hypermetropia.

Ophthalmoscope in hypermetropia.

Diagnosis.—In a case of hypermetropia, in consequence of the defect in the shape of the eyeball, or in the dioptric media, parallel or divergent rays entering the eye would, if prolonged, converge to a point behind the retina (Fig. 51); and conversely, rays reflected from any point in the retina will, on emerging from the eye, proceed as if they came from a virtual image of the point situated behind it; and being divergent they may be brought to a focus on the observer's retina and form a distinct image at a distance of fourteen or fifteen inches. That this

* "Manual of Instruction for the Guidance of Army Surgeons in Testing the Vision of Recruits." By Professor Longmore. Second Edition, p. 21.

Erect image seen at fourteen inches;

image is an erect one, may be ascertained from its moving in the same direction as the observer's eye; for instance, if the optic disc be the object under examination, and the observer turn his head to the right, the disc will follow to the right also.

In emmetropia, at three or four;

If the direct method of examination be employed in the case of an *emmetropic* eye, an erect image of the retina may be clearly defined at a distance of three or four inches, but only a very imperfect one can be seen at fourteen or fifteen.

In myopia, inverted.

In the *myopic* eye, an erect image cannot be seen at all, but at about fourteen inches, a well-defined inverted figure may be observed.

In the *hypermetropic* eye, an erect image of the retina may be seen at a distance of fourteen or fifteen inches.

Diagnosis of erect and inverted images.

The diagnosis in these cases may be much assisted by the following plan, proposed by Mr. G. Cowell:— "A finger of the hand not employed in holding the ophthalmoscope, is held up as an object for the patient to fix with the eye under examination, and in such a position that the observer may get an image of one of the retinal vessels. If the finger be then slightly moved to and fro, in a direction perpendicular to the vessel, the image will be seen to move with the finger when myopia is present, and in the opposite direction when the eye is hypermetropic."*

Flattening of eyeball.

If the hypermetropia arise from the eyeball being flattened from behind forwards, as it generally does, it may be detected by making the patient turn his eye inwards, when the peculiar flattened form of the globe will be noticed.

Far and near vision imperfect.

If we test the sight of a person suffering from hypermetropia with Snellen's types, we shall find that there is considerable imperfection of vision at both the near and far points; the larger types are proportionately better seen than the smaller ones, which the patient will naturally hold very close to his eyes, so as to gain the full advantage which the convergence of the optic axes affords him of increasing the power of accommodation, and also of enlarging the retinal image.

In looking at objects at a distance, as, for instance,

* *Ophthalmic Hospital Reports*, vol. v. p. 227.

No. XX. Type, at twenty feet from the eye, although the letters may be clearly defined at first, the accommodatory apparatus being brought into play to focus even parallel rays, the strain on the ciliary muscle soon becomes greater than the patient can bear, and its tension giving way, the letters become indistinct, and a tendency to internal strabismus is observed. If suitable convex glasses be now placed before the patient's eye, all these symptoms disappear, the rays of light being brought to a focus upon the bacillary layer of his retina; and this, in fact, is the correct mode of treatment in cases of this kind. It is quite possible that H. may be mistaken for M., for the far point is indistinct, and small type has to be brought close to the eye to enable the patient to define it clearly: but convex glasses placed before the eye of the hypermetropic patient at once renders diagnosis clear, the sight in H. becoming distinct, but in M. more indistinct.

Corrected by convex glasses.

Donders divides hypermetropia into three kinds:—

Three degrees.

1. *The facultative;* in which the patient is able to see well (with parallel optic axes) at infinite distance, with or without the aid of convex glasses, and his sight is generally sufficiently acute to enable him to read small print; but after a time symptoms of asthenopia arise.

1. Facultative.

2. *Relative hypermetropia;* in this form, the accommodation and range of vision are also good, but the patient is obliged to assist the action of the ciliary muscle by the internal recti, converging the optic axes on some point nearer than the object he is looking at, and he thus acquires an internal squint. The sight is always more or less defective.

2. Relative.

3. *Absolute hypermetropia;* in which vision is very indistinct both for near and far objects, the patient not being able to focus rays of light on the retina, however great the effort of accommodation, combined with the strongest convergence of the optic axes. On a superficial examination such a person might be mistaken for one suffering from amblyopia.

3. Absolute.

Hypermetropia may be *manifest* or *latent* (M. H.) and (L. H.). In cases of hypermetropia parallel rays of light not being brought to a focus on the retina the aid of the ciliary muscle is called into play, in order to increase the refractive power of the eye, even when employed on distant objects. And for near objects there is

a still greater effort of the accommodatory power necessary: the consequence is that in the course of time in every act of vision the ciliary muscle is brought into play until its action becomes an involuntary one; and in examining a case of H. we must take this fact into consideration, for in every effort of vision we have to deal with H.+the increased action of the ciliary muscle, and to discover the actual amount of H. in any given case, we must destroy the action of the ciliary muscle, paralysing it by means of a solution of atropine applied to the conjunctiva. Hypermetropia therefore consists of a certain amount of deficiency in the refractive powers of the eye which is *manifest* on an ordinary examination; but a further amount of defective refractive power also exists which is concealed by the action of the ciliary muscle, this is the *latent* hypermetropia. The total amount of hypermetropia in any given case therefore is constituted of H. M.+H. L.: and if the degree of H. is small, it may be entirely latent or overcome by the action of the ciliary muscle, so that it is not until this muscle is paralysed that we discover the H.; in cases, however, of this kind the sight is not only defective but becomes much more so if the tone of the muscular system is under par, or if the eye is over-worked and the ciliary muscle unable to bear the fatigue gives way and asthenopia results.

Measure degree of H.

To determine the degree of hypermetropia only one eye should be examined at a time, having completely paralysed its ciliary muscle by means of atropine: a solution of four grains to the ounce of atropine should be applied to the eye night and morning the day before the examination is made. We must ascertain the deficiency of the refractive power of the eye as compared with that of an emmetropic eye. As I have already remarked in the case of M., if a +10″ lens is placed before an emmetropic eye the patient will be able to define print clearly at 10″ from the lens, because the rays of light under these conditions fall as parallel rays on the observer's eye. But if this same +10″ lens be placed in front of an eye affected with H., in which the accommodation has been paralysed, it is evident that in consequence of its defective refraction the patient will be unable to define print at 10″ from the lens, but he may be able to see the test type clearly at 15″. Under these circumstances the difference between a

Paralyse accommodation.

Use of convex lens.