large barge moored to the *Oneota* was filled with cases of malarial fever of a pernicious type. We used water for drinking and cooking purposes that was boiled or distilled as on the *Valley City*. What I want to show particularly is, not only that malarial fever prevailed notwithstanding that the water for drinking and cooking purposes was boiled, but that it is not necessary to have a wet season follow a dry and warm summer to produce malarial fever or the plasmodium malariae. Up to Oct. 6, 1865, there had been no rain. The Ohio and Mississippi Rivers were very low, and along the banks of the Ohio in the vicinity of Cairo there was a green scum on the surface of the river, extending some distance from the shore. Yet, as I have said, there was malarial fever prevailing everywhere in that locality.

Again, in the Western States and in Pennsylvania malarial fever has been actually plowed out of existence. The agriculturist who, for the first time, turned up the soil, suffered the most from malaria, but as the soil was more and more stirred up the less severe and the less frequent would be the attacks, so that today in many localities where the disease was most prevalent, there are no cases of malaria. Was it the water that these early settlers drank, the food they ate, or was it the air they breathed by which the plasmodium malariae or malarial parasites were conveyed into their system?

I hope I have made myself plain on this subject. It is only by observation and experience that we can arrive at a true understanding in regard to this matter. The more plasmodium malariae that is taken into the system, the oftener the paroxysms of fever will recur, as every day, every second day, etc. Pernicious fever occurs in localities in which the plasmodium malariae or malarial poison is most intense and most concentrated.

CONVERGENT STRABISMUS.

A CLINICAL LECTURE DELIVERED IN RUSH MEDICAL COLLEGE.

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I. ITS ETIOLOGY.

We have read that a child's education ought to be started before its birth; and, in our opinion, the consideration of strabismus is incomplete unless we remember that the ancestral history of these cases often contains an account of one or more persons where the visual line of one eye deviated from the object looked at with the other eye. Such predisposition undoubtedly tends to the production of squint in the offspring. The young of all animals remain with closed eyes for a variable period after birth. The human offspring is no exception. Whether this is due to a sudden change from darkness to light, or because the retinal functional development is inadequate for useful purposes, or because the brain itself is dormant, or because of all these several conditions combined, is unknown. The baby automaton has not yet awoke to the necessities of vision. Its functions are of the lowest forms of life. Its brain, as such, is yet a blank. The first promises of intellectuality are evident when it opens its eyes about the eleventh day (Petersen) and peers around. For some time afterward its vision is general and not special. Its rolls its eyes around regardless of any single object and its attention can not be arrested for a moment by ordinary objects. The center in the brain is then awakening and its anterior prolongation, the optic nerve and retina,

is becoming aroused to active life, but as yet the perceptive visual centers of the brain are not alive to the requirements of binocular vision. The eyes roll according to the uncontrolled nerve explosions sent to the external ocular muscles. The complicated government of visual center over motor center is not yet completed, and will not be until the higher center can receive and appreciate the image of an outside object formed on the retina of the observing eye, in short, until the occipital cortex has grown into a sentient perceptive center and asserted its control over the motor centers of the muscles of the eye. The greater the illumination of an object the more quickly it arrests the infant's attention; hence a bright light possesses a first charm to the steady gaze. The retina and entire visual tissue need a strong impulse to whip them into useful activity. By continued practice the function of vision is developed and at last the perceptive visual centers can value at its true worth binocular single vision, and they control the motor centers of the nerves that pass to the eye muscles and so regulate their nerve explosions that the visual line of each eye accurately meets at the object looked at. Briefly, the cerebral function of binocular vision is established "by the end of the second month (Petersen) and we will assume at the same time that the acuity of vision of each eye is alike and perfect. In such a subject there is no likelihood of strabismus and it can only occur from acquired pathologic changes in the ocular tissues. Animals' eyes have a hypermetropic refraction and the newly born human eye is no exception. It is undersized until puberty¹ is reached and even then the majority of human eyes are slightly far-sighted.

The infant's eye being unduly short in its antero-posterior axis the vision of such an eye, in a condition of rest, is imperfect according to the extent of this shortening. In order to focus parallel rays from distant objects accurately upon its retina it must needs exercise its accommodation, because its dioptric system, unaided, has an insufficient refractive power for such rays. Such an eye is adapted only for convergent rays and these are not found in nature. Therefore this hypermetropic eye must either be contented with insufficient focal power, associated with a blurry retinal image and imperfect vision of an outside object, or it elects to use its ciliary muscle to relax its zonula and lens, so that the added refractive power thereby gained is adequate for punctate union of luminous rays entering its pupil. Within a limited range this function of accommodation can be exercised alone or without any associated convergence, and it is by such means that youthful far-sighted eyes can add to their established binocular vision the power of seeing distant objects clearly. With binocular fixation, therefore, and normal acuity of vision such eyes are free from the probability of strabismus. The infant considers only distant objects and in predisposed cases strabismus does not occur until the child's curiosity has called forth the desire to observe near objects. This intellectual accomplishment is not reached earlier than the second year of life and it is during this period² that our squint cases begin to develop. They increase numerically up to the sixth year and are of the convergent variety.

¹ Twelve to eighteen years of age. Landolt, "Accommodation and Refraction of the Eye," p. 444.

² According to Petersen (Amer. Journal of Insanity, July, 1896), a normal child begins to distinguish colors correctly about the age of two years.

We see that it is not the distant object that brings out the strabismus, but the nearer object. We have averred that parallelism of the visual lines was consonant with distant vision. The two visual lines were accurately fixed upon the far away object, we had no strabismus.

The near object has called forth a new function, viz., that of convergence of the eyeballs. The function of accommodation and convergence, save within narrow limits, act together. The eyes we have mentioned as seeing accurately at a distance without either of them deviating were somewhat hypermetropic, but the license existing between accommodation and convergence was enough to permit of sufficient exercise of the former for distinct vision, without calling forth the latter faculty. This amount of hypermetropia has been called *facultative* (Donders), and in amount, in our example, is insufficient for the development of squint.

A higher degree of far-sight can not thus be neutralized. The link of union between accommodation and convergence is now put upon the stretch and accurate vision, i.e., punctate focusing of rays upon the retina, can only be done by a greater refractive power of the observing eyes, while this can alone be accomplished by still greater contractions of the muscles of accommodation, and this stronger nervous impulse can not be exercised singly.

In the posterior part of the floor of the third ventricle of the brain and in the floor of the aqueduct between the third and fourth ventricles are several groups of nerve cells that give rise to separate groups of nerve fibers. The nerve fibers are gathered together into the third nerve trunk, but these separate groups of nerve cells give off nerve fibers that have separate and distinct distribution to the motor apparatus of the eyeball. Three of these central nuclei lie side by side and undoubtedly have intercommunicating fibers for the functions of the distal structures of distribution, save within narrow limitations, are always exercised together. I refer to the nuclei giving origin to fibers going to the ciliary muscle, the most anterior central group of cells; to the sphincter of the iris, the group equally forward and to the outer side of the ciliary muscle group; and to the internal rectus muscle, the group of cells in the median line immediately behind the ciliary muscle group. Neither does the proximity of origin of these fibers terminate the close relationship of function, because they travel side by side in the third nerve trunk and only separate where its lower division within the orbit gives off the short motor root of the lenticular ganglion. From this point the motor fibers to each internus travel alone and the fibers to the intra-ocular muscles after filtering through the ophthalmic ganglion travel together in the short ciliary nerves to within the eyeball and are supplied from the same plexus within the ciliary body, though they are not completely inseparable, as shown by numerous cases of separate paralysis of either the sphincter of the pupil or of the accommodative muscle alone.

Thus we see the close anatomic relationship of the functions of accommodation and convergence and find at the same time the reason for their almost³ simultaneous activity.

It is undoubtedly a fact that each of these nerve groups can transmit an independent amount of nerve force, but this is of limited degree and the function

of the three centers is practically an associated one.

Now we will suppose that our child, who is beginning to observe near objects, possesses a medium amount of hypermetropia (2 to 6 D.) and has established the faculty of binocular vision for distant objects. He may apparently see objects in the distance distinctly, for he does not deviate either eye from its proper line of direction. When he looks at the near object, however, the inaccuracy of his vision is of such a high degree for these divergent rays that he must needs contract to a still greater extent his accommodative muscles, and in doing so he oversteps the bounds of independent action of the ciliary groups of cells over those of the interni, and this excessive effort at focusing becomes associated with an excessive effort of convergence, with the resulting deviation of one eye; a sacrifice of binocular vision, but gaining a more accurate focusing of the object with the other eye alone. In short, a strabismus convergens is instituted, and seeing that it occurs only when looking at a near object it is called a *periodic strabismus*. At first this squint may not be constant for near objects, if the latter are large enough and well illumined. Its frequency of occurrence, however, usually increases until for near it becomes permanent and soon it occasionally appears for distance, while later it becomes a fixed condition for objects at all distances.

It may be observed that the squint changes from one eye to the other, either eye fixing the object. This variety is known as *strabismus alternans* and the vision of each eye is usually equally good. In the majority of cases however the eye that first deviates inward is the eye that continues to squint and sees less well. This is known as *strabismus concomitans*, because the squinting eye follows its fellow and the angle of deviation is always the same. In this latter variety of squint the vision of the two eyes may at first be equal, and in this as well as in other forms of strabismus when vision is present in the two eyes, a diplopia occurs, because the two lines drawn from the maculae through the nodal points of the two eyes do not meet on one and the same object. The eye whose visual line is properly directed has upon its most sensitive retinal area, the macula, an image of the object looked at, more distinctly perceived than the image of the same object that falls to the inner side of the macular region of the deviating eye, upon a portion of the retina with fewer cones and hence less sensitive in perceptive elements. Thus you see that the images cast upon the two retinæ do not fall on corresponding areas, hence double vision exists and the nearer these images are together, with retinæ equally perceptive, the less the difference in distinctness and the greater the annoyance this diplopia causes the patient. But strabismic children, if they realize its presence, do not complain of or mention this double vision.

If there exists in our little patient a still higher degree of hypermetropia (above 6 D.), together with binocular vision, the vision for distance may be so poor and the knowledge of the value of more perfect vision so little appreciated, and the efforts of accommodation so unavailing or unused, that the child appears to rest contentedly with the vision that exists, together with a condition of relaxation of its efforts of accommodation and convergence. In short, it retains its binocular fixation and is satisfied with its poor vision until the prolonged efforts of an insufficient accommodative power result in subjective

³ In point of time the contraction of the pupil occurs later. (Donders.)

symptoms of eye distress and headache, associated with positive inability to see small near objects in school work. The oculist is then appealed to, not because of the deformity of strabismus, for this is absent, but because of the eye distress and the insufficiency of useful vision. Convex lenses are prescribed that are an accurate measure of the deficiency and when worn the symptoms cease and the required studious work goes on satisfactorily, though usually with subnormal vision, because these eyes are not only illy formed, but also histologically imperfect.

In the foregoing illustrations we have seen that in the hypermetropia of low degree the accommodation was sufficient for perfect vision, without calling upon the aid of convergence, and binocular vision was maintained, with no strabismus resulting.

In our hypermetropia of medium amount the accommodative effort was so extreme for accurate near vision that it could not be exercised without calling forth an effort of convergence in excess of the requirements of binocular vision. Briefly, a deviation inward of the visual line of one eye had occurred, a strabismus was instituted and binocular vision was sacrificed upon the altar of more accurate focusing.

In the highest degrees of hypermetropia we have shown that binocular fixation is retained and accurate vision correspondingly suffers, although squint does not always occur. The preceding illustrations are the rule, but not the invariable rule.

In all, hypermetropia was present, and this error of refraction occurs in three-fourths of all the cases of convergent strabismus. The cause of the remaining one-fourth of the cases of converging squint remains to be explained. An eye with a normal refractive power, an eye that in a condition of rest of its accommodation, has the power of punctate focusing of parallel rays upon its retina; an eye whose dioptric system unaided has sufficient refractive power for perfect distant vision, an emmetropic eye, may be the subject of strabismus. Binocular vision may have been inaugurated but inevitably lost because of a loss of balance of the lateral eye muscles (Schweigger), a congenital weakness of the externi or a superabundant power of the interni, either congenital or acquired. This condition explains the cause of a majority of the remaining cases of inward squint, and the above muscular conditions combined have a very important bearing in the causation of the ordinary cases of hypermetropic squint, as we shall see when we consider the operative measures necessary for their cure.⁴

Again, a muscular weakness in the interni, usually congenital, but occasionally acquired from the exhaustion of overwork, even with a hypermetropic refrac-

tion, may permit of a divergent squint. The opposite is occasionally true with a myopic refraction, a refractive power that is relatively too great, an antero-posterior axis of the eyeball that is excessive, so that parallel rays entering the eye are brought to a focus in front of the retina, we may have a convergent strabismus, and this is due either to a superabundant power of the interni muscles or a deficient power of the externi. The adductive power of convergent strabismic eyes is commonly too great, may be congenitally so, may be acquired from constant effort at convergence with accommodation. The shortened distance between the origin and insertion of the internus as a constant quantity results in a permanent shortening of this muscle (Hansen-Grut's theory) and also of the superior and inferior recti.

Lastly, the more anterior insertion of the internus tendon—six millimeters from the cornea—gives it a great advantage over the weaker externus, whose tendon is usually eight and occasionally ten, or even twelve millimeters from the outer limbus corneæ. Moreover, the position of rest of the entire ocular muscles is one of slight convergence of the visual lines.

Other causes of convergent squint are found in a congenital amblyopia of the squinting eye (Schweigger 30 per cent.) whose vision is too poor to exercise any efforts toward the establishment of binocular vision. It permits itself to be rolled inward by the stronger internal rectus, and so remains. Even in eyes where one has a greater error of refraction than the other, so-called, *aniso-metropia*—the one with the greater error, hence the poorer vision, has the least hold over the binocular fixation, and occasionally gives it up altogether and permits the internus to sway the eyeball inward. It is the rule in concomitant strabismus convergens for the eye with the greater error to be the deviating eye. Again in spasmodic conditions of the interni, produced by central, distal, or general causes, a convergent squint occurs, stays for a variable period, may recur, and happens generally after strabotomy, or in the constitutional conditions of children. This form is known as an *intermittent strabismus* and is infrequent.

Lastly, young patients are prone to squint where an acquired permanent opacity occurs as the result of some preceding inflammation of the cornea. Binocular vision, if instituted, is surrendered because of the inaccurate vision of the affected eye and the strongest muscle turns the eye inward or outward according to the relative strength of the individual muscles.

There are exceptions to the rule in strabismus, as elsewhere, and a few examples of this condition do not conform to the foregoing causative explanations. We occasionally see a case of squint, where only a lower degree of hypermetropia is present; where distant vision is accurate; and where the only deficiency we can find in the case is one of markedly diminished amplitude of accommodation for the age of the patient, an excessive convergence is instituted to increase an insufficient accommodation.

One of these cases I have lately had under my care where a patient, age 16, had an alternating convergent strabismus of 60 degrees with 20-20 vision in either eye without glasses, and who developed under atropin-paralysis only a total hypermetropia of 1 D. with the right eye, and 1.50 D. with the left, and who, after the atropin effect had entirely passed off, read with these glasses, either eye alone, 0.60 type of Snellen at a near point of eight and three-fourths inches (22 centime-

⁴ The last case of convergent squint I showed you was due to a combination of hypermetropic astigmatism, amblyopia and a lack of balance of the lateral muscles of the squinting eye. The patient, a girl of 18 years, had had a tenotomy of the left internus when 12 years of age, but objected to the use of glasses afterward. She appeared with a still present but very variable convergent squint. A parallelism for the distance but at 5 inches now, a deviation inwards of 15 degrees, and again 30 degrees, and still again an associated movement of the squinting eye outward, a divergence in fact being present. Yet in extreme abduction the left or squinting eye failed to roll out nearly as far as the other eye, even though a tenotomy of the opposing internus had been done six years ago. Here was present a marked weakness of the left externus muscle. The vision of the straight right eye was 20-40—; that of the left 20-200, while under atropin-paralysis that of the right eye was 20-200 and of the left eye 8-200. With each eye +3.50 D S C + 1 D cyl., axis 90 degrees, the right eye had 20-30 and the left 20-200. Therefore the best vision we could get with the straight eye was only two-thirds normal, and with the deviating left eye only one-tenth normal, yet the refractive condition of the two eyes was the same. The squinting eye was very amblyopic and besides had an anomalous muscular condition causing an ever variable direction of the eye, and the principal annoyance of which the patient complained was a constant diplopia. Further operative procedures were inadvisable and the above glasses were given to be worn constantly.

ters), showing an amplitude of accommodation of only 4.5 D. whereas it ought to have been about 11.5 D. at that age. We had a deficiency of 7 D., in short, the accommodation of a person of 40 years old. An advancement of each externus, with the requisite glasses for distance and near, resulted in a complete removal of the deformity. Another instance, where, with a high degree of hypermetropia, we have deviation inward, an example of this kind I have recently shown you in a hypermetrope aged 7 years with a Ht each eye of 7 D. Again, where, with a difference in the amount of the error of refraction in the two eyes, the one which has the lesser degree is the strabismic eye. The child recently before the class furnishes another, or central etiologic cause. She fell several feet one and a half years ago, and injured the occiput. This was followed by intra-cranial symptoms and intense headache, and soon afterward a concomitant strabismus inward and upward of the right eyeball, developed and has remained. The lateral deviation measured five millimeters and the ophthalmoscope showed a secondary optic atrophy most advanced in the right eye. As an observation, the retinoscopic test gave a total hypermetropia (under atropin) of the right eye, of 2.50 D., whereas in that of the left, straight eye, the amount was 3.50 D. Whether this error of refraction had any bearing on the production of the squint is a question. The more probable cause is the poorer vision of the right eye permitting the suspension of binocular fixation, together with the excessive action of the right externus muscle. The child is in her eighth year and was taken from school because of her failing eyesight.

One other case, is of retinal pathologic causation, and, in point of time, the lesion that was the immediate cause of the strabismus convergens was congenital, yet the squint did not show itself until the second year of life, when the continued functions of accommodation and convergence were established for near objects. The cause of the squint in the left eye is due to a macular destruction of the retina from a sub-jacent choroidal atrophy. The latter of small area, sharply defined, single and due to a prenatal circumscribed choroiditis. This boy, now about 8 years old, always closes the squinting eye when looking at near objects, because of some interference with accurate vision of the other eye, and though he can not explain it, it is most probably due to the recognition of the false image of the misdirected eye, a diplopia. The refraction of the eyes is emmetropic; therefore, the only explanation of the squint is that of the macular lesion of the affected eye, and the latter permits itself to be dragged inward by the stronger internus muscle.

There are also other exceptional causes of strabismus but all of these together do not invalidate the foregoing teaching. They only place us on our guard in our investigations; perfect our methods; and make of us more accurate observers. A consideration of the etiology of strabismus convergens would be incomplete without paying homage to that master-mind of Donders, of Utrecht, who thirty-three years ago, in his immortal work: "Accommodation and Refraction of the Eye," gave to the medical world the first clear conception of the causation of convergent squint; stated that 77 per cent. of the cases were due to hypermetropia; and placed the proper value on the use of convex lenses for the correction of the anomaly.

II. ITS MANAGEMENT.

When considering the etiology of strabismus con-

vergens we concluded that there were three quantitative degrees of hypermetropia that especially required our attention, and that the cases of medium amount (2-6 D.) of this anomaly furnished three-fourths of our cases of squint. The possessors of a low degree (up to 2 D.) of far sight, are often not seen in practice until the middle period of life, when near work becomes tedious and subjective eye symptoms force the patient to wear glasses some years earlier than the usual presbyopic time.

Those children who have the highest amount of hypermetropia (over 6 D.), are dismissed from school because they can not see the markings on the black-board and appear mentally dull. They are advised to see an oculist, glasses are fitted and they return to their studies. What are we going to do with our young hypermetropes who squint? Estimate the amount of their error under atropin and give fully correcting glasses, to be worn constantly during the waking hours, together with the use, for a time, of atropin daily to annul accommodative efforts and break off the formed habit of over-convergence previously needful for accurate vision, especially of near objects. If we can demonstrate an amblyopia of the deviating eye, supposedly due to non-use, we stop using the atropin first in this eye, and advise⁵ the practicing of its vision alone for a time, thus giving this eye an advantage for near use. Later stop using atropin in the good eye and still practice with the weaker eye, twice daily for an hour or more, the good eye being covered at the same time.

The amount of error is estimated usually by means of retinoscopy (skiascopy), this plan being more accurate than the ophthalmoscopic measurement, and even where our patient is able to read type, the subjective test is less reliable than by the first objective method mentioned.

The glasses given are changed as needed and are worn faithfully, until we are assured that they will not alone avail for the cure of the deviation, and until the patient is old enough for the operative procedure. In cases of supposedly spasmodic squint it is well to defer operative procedures indefinitely, also in cases of alternating strabismus, and in cases where repeated measurements give variable amounts of deviation, be slow to operate.

In squint cases where the error of refraction, on re-examination, is decreasing, and in families where strabismus has been known to continuously disappear, do not operate until after puberty or full growth of the eyeball. The correcting spectacles, without or with operation, must constantly be worn to avoid recurrence due to the still present hypermetropia. Now we have remaining the cases of squint where intracranial or retinal causes produce the deviation indirectly by the resultant poor vision. If operation is decided upon in these cases it is solely for the cosmetic result. Here we can not expect to institute what has never before been established, viz., binocular single vision. In fact, in those cases that we have still left as suitable for operation, we can not expect to regain this great desideratum—the aim of all of our surgical procedures—in more than 10 to 20 per cent. We may get parallelism in 50 per cent., and we expect satisfaction

⁵ Blindfolding the sound eye and practicing the deviating eye was ninety years ago one of the successful methods of correcting strabismus, and Mackenzie quotes (Amer. Ed., 1885, p. 367) the case of Professor Roux, who thus cured strabismus in himself of thirty-five years' standing. Beer (loc. cit.) was in most cases successful "by binding up the sound eye every day even for a couple of hours only."

in 80 per cent., or, by our present methods, a success in practically all of our selected cases. That the subject of the operative management of strabismus is still unsettled in its entirety, is evident from the continued discussion of the subject in the journals and in the special medical gatherings throughout the world. Even as lately as the meeting of the Ninth International Medical Congress (Washington, D. C., 1887), several members admitted that the correction of strabismus was not a satisfactory operation.

The first operation on an ocular muscle was done by Stromeyer in 1838 on the cadaver (Mackenzie, p. 369, Amer. Ed. 1855). "Pauli was the first to attempt it on the living, but the eye was unsteady; he divided the conjunctiva but could not divide the muscle" (Mackenzie, pp. 369, 370).

Later, in 1839, Dieffenbach operated on a living patient, cutting through the belly of the muscle. The posterior half of the muscle then retracted, so that no reattachment to the eyeball could take place. The complete paralysis of the cut muscle was followed by a divergent squint. Such result was observed to be invariable after this method of operating, and the procedure fell into great disrepute (Fuchs, p. 710). Böhm then suggested a section of the tendon of the deviating muscle, and such method has been continued ever since.

Von Graefe improved the technique of the operation, showed how to increase and diminish the effect, and instead of cutting the tendon, when in the grasp of forceps, he introduced his hooks and the section was made on these. Both of the latter methods are still in use. The result from the Dieffenbach operation was so disastrous that the subjects of it presented material for further corrective procedures, and Jules Guérin, in 1849, operated on these cases of divergent squint with the view of advancing the attachment of the cut internus toward the cornea. He dissected from the inner portion of the sclerotic all the superjacent structures—conjunctiva, Tenon's capsule, internus, and far back toward the equator of the eye. He then placed a thread *through* the sclerotic on the external side of the cornea, and by drawing on both ends of the thread he rotated the eyeball inward to the desired extent, and fastened the thread ends, by strips of plaster, to the skin of the nose. In this way it was hoped that a more anterior attachment of the severed internus would take place. The thread was left *in situ* several days, but it was observed to cause serious inflammation in some cases, now known to be due to a traumatic cyclitis, because of the depth of insertion and the location of the thread.

Now the ingenious von Graefe came to the rescue, and proposed the so-called *thread operation*, which differed from Guérin's plan only in that the internus was not severed from the sclerotic immediately at its insertion, but a short distance behind it, so that a stump of the tendon was still adherent to the sclera. Through this stump the thread was passed and the eyeball guyed in and fixed, as before, in the desired position.

Since then thread methods of advancement have been greatly improved, and several plans have been followed—some consisting of three threads, some of two threads, some where a single thread is advocated. They all agree in attaching the thread or threads directly to the severed tendon of the muscle to be advanced, and stitching the forward end or ends to the eyeball in front, where traction on the thread

draws forward the muscle and tilts inward the eyeball to the requisite extent, and so retains the two fixed points for the necessary days required for the cicatrization of the wound at the site of the tendon of the advanced muscle.

From this history you will see that we have established two procedures, one of tenotomy of the insertion of the tendon of the internus in cases of convergent strabismus; the other of advancement of the retracted muscle subsequently to a former tenotomy of it, in order to correct the opposite deformity, a divergent strabismus. These operations on the internus tendon are equally applicable to that of the externus, though rarer; also to those of the other straight muscles of the eye—the superior and inferior recti—though operations on these tendons are still less frequently required.

We are considering a convergent squint and its correction, and we want to lessen the over-effect of this internus muscle on the deviated eyeball. As we have seen, when considering the etiology of squint, that this muscle usually possesses a superabundant strength, when compared with the often congenitally weak externus, and that owing to a continuation of the deviation a permanent shortening of the distance between the origin and insertion has occurred. Besides, its anterior attachment to the sclera is always further in front of the center of rotation of the eyeball than that of the less favored externus.

The indication is then plain; we must increase the distance between the origin and insertion of the internus muscle, or weaken its strength, or both, in order to destroy its over-effect on the deviated eyeball.

How are we going to do this? 1. By displacing backward the anterior attachment of its tendon to the required extent. In cases where the deviation does not exceed three millimeters, a careful section of the tendon of the internus at its insertion is usually sufficient to correct it. In cases of four to five millimeters, if tenotomy of the shortened internus insufficiently corrects, the teaching has been to free the lateral expansions of the tendons that are derived from the capsule of Tenon, where the muscle passes through the latter, near the equator of the eyeball. These connective tissue fibers on each side of the tendon are cut to the requisite extent. If the eye then fails to roll outward sufficiently, a guy suture is inserted vertically through the conjunctiva, just beyond the outer margin of the cornea, and one end passed through the outer commissure of the eyelids. The two ends are then tied, with traction sufficient to drag the eye outward to a correct position. This traction results in a displacement backward of the cut tendon, and the thread is left in from a few hours to two days.

Where the strabismus measures five to six millimeters, the cutting of one tendon is insufficient for correction without displacing backward the muscle so far that the resulting loss of motion inward impairs the future usefulness of the eye, when observing objects situated in the extreme nasal field of this eye. The operated eye then fails to follow the other eye, and binocular fixation does not occur. Hence, the operation effect has to be divided between the two eyes. The deviating eye is tenotomized in its internal rectus, and after waiting a couple of weeks the remaining squint is removed by a sufficient operation on the internus tendon of the other eye. Thus the inevitable loss of motion that follows all successful tenot-

omies is divided between the two eyes. Where the strabismic deviation reaches eight millimeters the last directions are carried out, except that the lateral expansions must also be invaded with the scissors, in order to get a sufficient result. When the deviation is over eight millimeters, the teaching has been, and still is in many quarters, to make a simultaneous and very free tenotomy on each internus, and if the effect, after healing, is still insufficient, to again cut the internus of the eye that retains the best motion inward. Sometimes this extreme procedure proves insufficient and both muscles have been tenotomized a second time, and such eyes may then possess a parallel position for distance, but too often their power of convergence is so reduced, that for near use they are a source of great trouble and anxiety to their possessor, if indeed they do not later give up the fight for binocular single vision, one eye making an associated movement while the other fixes—briefly, a divergent squint occurring as the final result of over-operation. The latter effect may occur at any time from one to two years after operation, and though often seen after excessive operative procedures, yet it occurs very frequently after ordinary and legitimate tenotomies. Unfortunately, we have no positive means of foretelling its occurrence in the latter cases. Tenotomy of the lateral ocular muscles is a very simple operation, so far as finding and cutting the tendons is concerned. Very little anatomic knowledge, steady hands, a forceps, scissors and, if you wish, a pair of hooks, a blepharostat and a solution of cocaine, are all that are required. We can not foretell positively in any case the results we will accomplish by such cutting.

The first internus tendon I ever cut was in a boy of 14, and without the slightest immediate change in the direction of the eye. I inserted into the wound made the smaller von Graefe hook, and made excursions clear back to the equator of the eyeball, and laterally in both directions, thus breaking down and cutting all the loops of tendon and connective tissue brought up on the hook, but still the deviation remained unchanged. I was nonplused, and felt confused, for others were present, so I stopped, knowing that there were matters in squint that were either not in the text-books, or I had failed to read them. My case was not a paralytic squint. The boy disappeared, without a correction, and I went to further observation and soon saw the same thing occur in the practice of the best men, two of whom had one case each where, after a tenotomy of each internus, there was no effect, and one put on guy threads and the other stopped operating and said nothing. A second head of insertion uncut and far back is not a sufficient explanation in these cases, for often we can not find it after prolonged search. Paralysis of the externus is excluded, as the eyeball is rolled directly outward. A shortening of the superior and inferior recti muscles is the common cause that keeps the eye from rolling outward. For the latter reason, the backward displacement of the cut internus is also limited, and besides a tenotomy of it, we need an opposing force to the other shortened and uncut structures. We have mentioned a guy thread, but this cuts out and is of only temporary use, while it is a bungling method of correction.

2. When considering etiology, it was seen that the more posterior attachment of the externus tendon, together with the relative weakness of this muscle, placed it at a great disadvantage; besides, when the

distance between its origin and insertion is increased by the deviation of the eye inward, in convergent squint, it can readily be seen that, next to the cutting of the shortened tendon of the internus, a strengthening of the effect of the externus on the eyeball ought to be accomplished. As a matter of physics let us shorten the distance between the origin and insertion of the externus by cutting its tendon at the sclera, removing two to four millimeters of it, and reattaching the remaining tendon as far forward on the sclera toward the cornea, as the requirements of the case demand.

These two operations—a careful tenotomy of the shortened internus, together with a simultaneous shortening and advancement of the externus—have scored a great advance in the more certainly beneficial results of strabismic operations.

This combined operation was first advocated only in cases of divergent squint, where a tenotomy of the externus alone never exceeds a correction of over three millimeters, and where such section is wholly insufficient for a satisfactory correction. Of late years, more especially under the able advocacy of Landolt, this procedure has been applied to convergent squint, and has grown in favor so rapidly that at present it promises to soon be the only procedure for the correction of squints of over three millimeters in extent. The results are positive and can be more accurately calculated, but in the cases where it is most used it is found necessary, for a thorough correction, to advance the externus of both eyes—not simultaneously, but on the second eye after an interval of two weeks or more.

The objections to tenotomy are its uncertainty of results, the opposite deformity occasionally occurring, and the loss of motion invariably following the successful correction of the deviation. These conditions are absent after advancement; in fact, the eyeball retains its position in the orbit, is directed permanently correct, and its motility is greatly improved.

Most modern ophthalmologists consider that tenotomy ought to be limited to cases of motor insufficiency, latent squint, and to the slighter actual deviations, but Landolt believes that in all these cases advancement offers greater advantages, and he claims that in his hands it has never caused an over-correction.

There are advocates of an advancement of the antagonistic muscle alone; the externus in convergent, and the internus in divergent squint, without a simultaneous tenotomy of the deviating muscle. There are others who believe in a partial tenotomy of the shortened tendon, leaving a few strands of the tendon proper at its upper and lower border, associated with an advancement of the antagonistic muscle, desiring to only temporarily weaken the deviating muscle until the advanced muscle gains a firm reattachment (Beard). In the two latter procedures an increase in motility of the operated eyeballs is very marked, but the certainties of full correction are less assured.

Modifications of the foregoing procedures, in different cases, are carried out according to the dictates of the various advocates, and no consensus of opinion has yet limited different methods to special conditions. One certainty is accomplished because of the better results achieved, viz., that the champions of advancement are increasing greatly, and the cases where tenotomy is alone required are rapidly disappearing from our observation.