

# **On the tests for muscular asthenopia and on insufficiency of the external recti muscles / Henry D. Noyes.**

## **Contributors**

Noyes, Henry D. 1832?-1900.  
Ophthalmological Society of the United Kingdom. Library  
University College, London. Library Services

## **Publication/Creation**

[Copenhagen] : [publisher not identified], [1884]

## **Persistent URL**

<https://wellcomecollection.org/works/hv4hshs6>

## **Provider**

University College London

## **License and attribution**

This material has been provided by This material has been provided by UCL Library Services. The original may be consulted at UCL (University College London) where the originals may be consulted.

This work has been identified as being free of known restrictions under copyright law, including all related and neighbouring rights and is being made available under the Creative Commons, Public Domain Mark.

You can copy, modify, distribute and perform the work, even for commercial purposes, without asking permission.



Wellcome Collection  
183 Euston Road  
London NW1 2BE UK  
T +44 (0)20 7611 8722  
E [library@wellcomecollection.org](mailto:library@wellcomecollection.org)  
<https://wellcomecollection.org>







*With Compliments of*

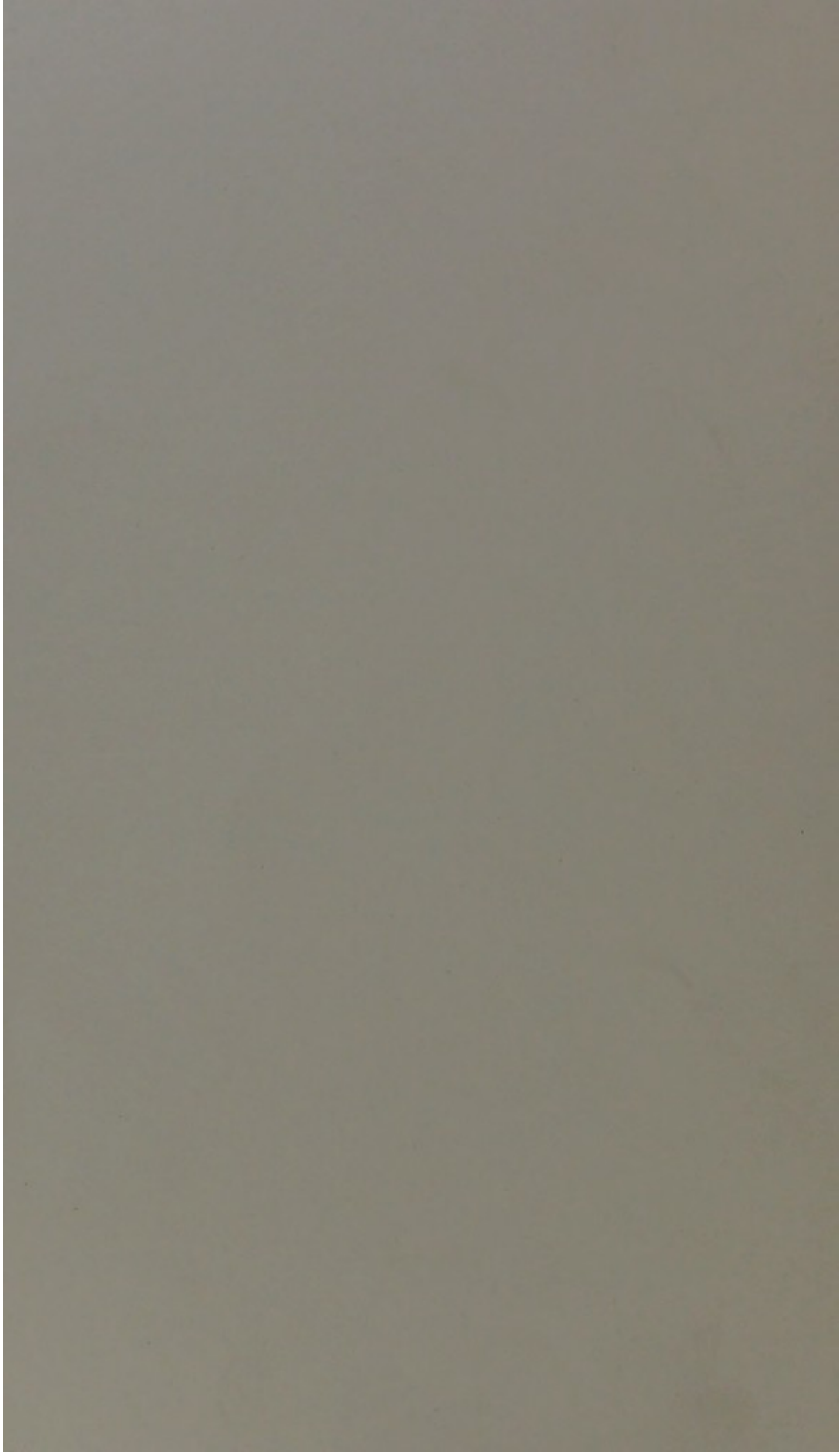
HENRY D. NOYES, M.D.,

233 MADISON AVENUE,

NEW YORK.

*August 1, 1885.*





On the tests for muscular asthenopia and on insufficiency of the external recti muscles.

Dr. **Henry D. Noyes**, de New-York.

That complex of symptoms which may arise in attempting to use the eyes in near work and which we know by the vague yet convenient name of asthenopia, consists of irritation of the mucous membrane of the lids and of the palpebral border, of indistinctness of vision, of pain, of weariness, of photophobia and of various remote and less frequent symptoms in the eyes and in the head, and occasionally also in other parts of the body.

The factors which occasion asthenopia are the accommodation and the muscles which move the eye balls, and presiding over these is the centre in the brain, which maintains communication with them by the afferent and the efferent nerves. The pathological status arises when any one of these factors is disturbed, but while one of them, by its being primarily disordered, may be the principal cause of trouble, all are so intimately associated, that when one factor is disturbed, all the factors participate. It is true, that there are cases, which may be correctly designated as asthenopia accommodativa, others as asth. muscularis, others as asth. centralis or perhaps better as asth. psychica. — The sub-division which designates the retina as a primary cause of asthenopia and speaks of asth. retinalis, I do not think can be successfully maintained. Asth. accommodativa is most often associated with, and dependent on, errors of refraction, but it may be simply the effect of overwork in a normal eye. Ast. muscularis may be idiopathic, i. e. due to intrinsic weakness of a muscle or muscles, or it may be reflex and really come from imperfect innervation. Asth. centralis may come from imperfect nutrition of brain centres, or may be a want of developement of the faculty of psychic fusion — in other words, the brain may refuse to combine into one conception the double impression conveyed by two eyes.

The first category we do not primarily consider in this paper. The third category may be incidentally referred to because it has such inextricable relations with asth. muscularis. Asth. accommodativa does also intermingle with muscular asthenopia and cannot be neglected as it bears upon the latter.

I speak of asthenopia muscularis as idiopathic and as reflex. In the former class I find such a state of the muscles, that they are intrinsically incapable of such exertion or endurance as is demanded from them. They may be said to be actually below par as muscles. The symptoms, to which this state give rise, will be promptly and permanently relieved by means, which physically aid them in their duty. By reflex muscular asthenopia I understand a state, in which the muscles also fail to do their full duty, not primarily because of their intrinsic weakness, but as a result of impaired central energy (by which I do not mean a want of central fusion). Impaired central or cerebral energy ensues after debilitating diseases, from exhausting mental labors, or from depressing emotions.

1847524



The distinction is a practical one, if not founded in demonstrable facts of pathology, and it asserts its *raison d'être* for the last class in the comparative inefficacy of optical contrivances, in the value of general hygieinic measures and rest, and in the happy effect of recovery from constitutional or remote local disorders. All the above mentioned forms of asthenopia mingle together in most varying proportion in special and almost in every individual case.

Muscular asthenopia may go so far as to give rise, under certain conditions, to diplopia (provided the person have central fusiou power), but it is not the rule to find this symptom. In this respect, it is to be distinguished from paresis, and from paralysis; it is somethig less even than paresis, and we may call it exhaustion. Whether that exhaustion be in the efferent nerve force or in the muscular substance is not now, nor need it be, our inquiry. We are familiar with it in other conditions. We know it among those, who contend in boat races, or in walking or in running matches, or in preparing for prize fights, as being overtrained. In other words, it is exhaustion from excessive labor, und it is a very different thing from either paresis or paralysis. Such exhaustion of general muscular force as well as of eye muscle force is often attended with neuralgic pains as well as by a great sense of weariness.

The demands of binocular vision compel each eye to maintain by means of its muscles a definite position, which shall enable it to coordinate with its fellow in the most exact manner. Unless we are asleep or, as we say, gazing at vacancy, there can be no rest strictly speaking for the eye muscles.

This imperative demand also is imposed upon the eye muscles without the existence of binocular vision. I have records of cases of muscular asthenopia, where one eye was so amblyopic as not to be of any use, or where one eye was deviated far from the line of binocular vision. Again I have records of muscular asthenopia in patients, who had only one eye. But assuming binocular vision, we have muscular asthenopia where the effort to maintain coordination is too great for the permanent capacity of the muscles. This effort is always greatest, when we are employed upon near work. In this function the act of convergence takes the conspicuous part, and has attracted most attention; but the state af convergence presupposes an opposing power which shall give steadiness and regularity to the act, and this is divergence. — In these functions all the eye muscles partake, but we single out the recti interni and the recti externi as the most important.

To the latter muscles as having an important function, and as having been in some measure overlooked in the study of asthenopia I beg to call attention.

It may be proper to make another preliminary statement. Having said that the motor eye muscles must always be in a condition of tension, if not of active effort, while the act of binocular vision is maintained, it is right to call attention to a distinction in terms which has not always been duly appreciated, and has made some dispute.

The word equilibrium is used to indicate, that the muscular forces are so balanced that the visual axes point upon the same object, and it is assumed that this is identical with a state of repose. There may be equilibrium without repose. Repose does not signify the absence of muscular tension but means the degree of tension which it is easy for



the muscles to maintain; it is comfort in activity, not absolute relaxation. On the other hand equilibrium, as we ascertain it by various tests, whether it be by the vertical diplopia test of Graefe, or by the peculiar use of a prism when one eye is screened, which Alfred Graefe uses, or whether it be assumed to exist in some arbitrary relation between convergence and divergence, equilibrium of the visual axes, however ascertained, is not the same thing as repose of the muscles. Repose is the combined result of adequate power of accommodation, of muscular energy, and of cerebral and general function. It exists when work in near objects can be performed without irritation, fatigue or pain. When this is not the case we have asthenopia, and yet our tests may proclaim muscular equilibrium.

Another pregnant observation grows out of the above remark viz. that we have no right to assume, that unless each one of the above three factors takes part in a given degree there either cannot be asthenopia or that there must be asthenopia. Facts disprove such a theoretical assumption. There may exist a great degree of muscular insufficiency as declared by tests, and no asthenopia be present. I introduce one situation of such a kind, in which the externi would be accused, and in which no sign whatever of asthenopia existed.

Case 1. Dr. James L. M. aet 29. Physician. New-York. Examined without atropia has

$$\left. \begin{array}{l} \text{O. D.} + 48c \ 90^0v = 20/12 \\ \text{O. S.} + 30c \ 90^0v = 20/18. \end{array} \right\}$$

There is no spasm of accommodation. The state of his muscles is as follows with correcting glasses

at 20' adduction = $35^0$ abduction = $5^0$ } $40^0$ with vertical diplopia = $5^0$ convergence.	at 12" add. = $37^0$ abd. = $25^0$ } $62^0$ v. d. = equilibrium.
--	--

He never makes use of any glasses for any purpose, he uses his eyes abundantly, he never experiences any pain or inconvenience, either in reading or writing, or in the use of the microscope.

In this person the normal state of A and the robust state of the central and peripheral nervous system neutralise the want of equilibrium, which is exhibited by vertical diplopia at 20 feet. Still another explanation is possible in such a case viz. that for this person a low angle of convergence for distance is the state of repose as distinguished from equilibrium. In him with hyperopic astigmatism some tension both of A and of muscles would be natural. Yet the absence of both accommodative and of muscular asthenopia seems to me most naturally to be explained by the want of excitability in, or rather, by the abundant and quiet vigor of the nervous force.

It is doubtless true that for all persons the state of repose in the relations of the visual lines will not be identical: they may have for distant vision, parallel divergent or convergent axes. Doubtless for distant vision the normal state for emmetropic eyes is parallelism. For corrected ametropic eyes it should be the same, but variations arise through differences in the form of the skull affecting the shape of the orbits, through the varieties in the interpupillary distance, and through inherent differences in the capacity of the muscles. It is not however a safe assumption, in my opinion, to take for granted that a



given case departs from the normal state viz. parallelism of visual lines for distance, unless experience proves that this condition cannot be maintained. To assume this situation would in very many cases put an end to all investigation as to the causes of asthenopia, while on the other hand it may become the explanation of the benefit conferred by prisms, which experience will already have demonstrated. For some cases, where by tenotomy an improved relation has been established among the muscles, it may not be found possible to secure parallelism for distance: then either convergence may remain and the deficit is to be made up by prisms. — In one case of myopia where tenotomy had twice been performed the ultimate status of repose was found in partial correction by glasses of M. and in leaving the visual axes in convergence. The decision of what may be the state of repose in a given case is the very object of investigation and in my judgement requires the methods to ascertain it, which I shall presently discuss and which in my recent cases I have followed. When this is decided we shall be fully prepared to adopt appropriate and successful treatment.

It remains in these introductory statements to refer to the subject of deficient or absent central or psychic fusion. That want of this power plays a most important part in strabismus is perfectly well established. That it may exist in minor degree in asthenopia need not be denied, but it remains, in my judgement, to be proven. I utterly disbelieve in it as a frequent occurrence. I am aware of Krenchel's paper in Graefe's archives, vol. XIX, abth. 1. 142, in which he sets forth the potency of this factor in strabismus. That no one doubts. But for asthenopia I think the argument is a priori in favor of a central capacity for fusion, else the chief motive for coordination would be wanting, and we should not have that struggle among unharmonious factors which constitutes asthenopia. I am aware that Dr. Hansen Grut lays stress on this factor in asthenopia, but I think we have a right to demand proof of its existence of the same kind which can be adduced in its favor in cases of strabismus. As a matter of fact we find all cases of asthenopia are capable of binocular vision and the complaint is that they cannot comfortably maintain it. I leave out of view the cases already referred to of monocular muscular asthenopia and those too in which one eye is excessively amblyopic.

In anisometropia the pain which may exist presupposes psychic fusion. There are certain cases in which the muscular power is extremely feeble as shown by low adductive and abductive power and by the tremor of the globes as they move from side to side, but if in these cases it is contended that the muscles are not weak but that the fault lies in defective innervation, I do not care to dispute the matter, but this assertion is not proof that psychic fusion is wanting; on the contrary the stereoscope and prism tests abundantly demonstrate its existence. A case of this nature is as follows.

Case II. Michael D. aet 49. Machinist living in Ilion, New-York. Had great pain in eyes for 12 years — his work obliges him to look upwards continuously to clean the shafting of the machinery, and this he feels gives him pain. Is wholly unable to read. Has many neurotic symptoms in the bladder and lower extremities. Not examined for clonus of the knee joints. Is physically strong. When he turns his eyes to the extreme right or left they exhibit great tremor. Any fixation is painful. By prisms he shows



at 20' add. =  $5^0$  }  $10^0$   
 » » abd. =  $5^0$  }  
 » » v. d. =  $2^0$  div.

When one eye is covered and the other fixes on the finger held at 3 inches, the covered eye turns very far outward. In treating this man by convex prismatic abductive glasses, by gymnastic prisms and by nerve tonics, no improvement of any value was gained. He possessed binocular vision and if the low state of his muscular energy should be assigned to exhaustion of nerve force rather than to weakness of muscular structure I would not dissent: but there was certainly no defect in psychic fusion.

An instance of want of psychic fusion is the following:

Case III Rev. W. M. I. clergyman aet 30 New-York, seen in Oct. 1882. Suffers much from head-ache, reads all day, has pain in eyes, rarely has any blur of print. Uses his left eye almost exclusively and then permits the right to diverge. When excited, as in preaching, the right eye shows a marked divergent strabismus. Usually this does not appear, but when made to follow the finger moving before him at 10 inches the internus of the right eye twitches and thus shows its weakness. Without using atropine:

O. D. v. =  $20/20$   
 O. S. v. =  $20/20$ .

Will not accept glasses. By ophthalmoscope estimate H  $1/48$ . Notwithstanding normal vision in each eye it is impossible to make him see double, although he will see the image with each eye alternately. He declares, that his eyes have always had this peculiarity.

Evidently there is no psychic fusion, and in my judgement it is due to congenital weakness of the right Rectus internus, which prevented the accomplishment of proper coordination of the visual axes in early life, and hence failed to establish the central faculty of fusion.

To come now to muscular asthenopia. The tests for its existence are those, which Graefe gave us, viz. first the deviation of a covered eye while the other fixes a near object; secondly the approach of the finger close to the eye below the horizontal plane to elicit possible deviation, and thirdly the use of prisms. The use of prisms is to ascertain the degrees of adduction and of abduction, and also by placing one with its base vertical to cause uncontrollable diplopia, which, when it occurs will bring out, as Graefe supposed, the true status which the muscles will naturally assume, and this last he called the equilibrium test. The first two methods of examination may be passed in silence — as to the use of prisms to ascertain the energy of the eye muscles, I beg to remark, that they cannot give us an absolute measure of muscular power, such as we may apply to other muscles, when we lift a weight or compress a spring. The test is only relative and merely indicates the difference, which subsists between opposing muscles. Adduction and abduction in eye muscles only mean what resistance one set of muscles can offer to another set of muscles, not what resistance one set of muscles can offer to a definitive and measurable force like the earth's gravity or the elasticity of a spring. It therefore follows that our judgement about the inherent strength of eye muscles is vague and not precise. On this matter of estimating absolute strength I think valuable help is given by noting,



whether the eyeballs as they traverse an arc of movement in various and especially in extreme positions, accomplish the effort with perfect regularity and smoothness, or whether they twitch or jerk or give a little sudden jump, at some point in their movement. Slight rotatory movements due to debility of the obliqui are not rare, and great tremor at the outer canthi or at the inner canthi are very significant of weakness of the externi or of the interni. Diplopia at extreme positions of fixation on the temporal sides is a symptom which cannot be overlooked because it gives a useful hint. It does however remain true that we have no test so good as prisms used to give the adduction and abduction, and this may be said of them, that if they only tell us differences, these differences will vary in proportion to the magnitude of the factors to be dealt with. When we take the sum or difference of two factors the totals will not be large unless the factors are large. That is, 8 and 4 give the same difference as 16 and 12, but the sum of the two sets shows a different value in the factors. Hence if adduction and abduction respectively show us only differences between antagonists, the sum of adduction and abduction will give an estimate of total muscular power, and if adduction and abduction be each high or low, we are thereby put in possession of knowledge which has real value.

In my examinations of asthenopia I now investigate the adduction and abduction for the distance of 6 meters or, as I usually say, 20 feet, and also for the near point, or rather for the working point: one may be called the punctum remotum, the other the punctum agendi (not the punctum proximum). In testing cases of ametropia glasses will be required for the punctum remotum, whether spherical concave or convex, or cylindrical glasses. At the punctum agendi the glasses which may be needed for presbyopia or for myopia or for astigmatism are to be ascertained and to be used in testing the muscular power. I often make a provisional test without such glasses, merely for the sake of comparison. At the place of near work the effect of glasses in modifying the accommodation, both by abating it as with convex glasses and by increasing it as with concave glasses, at once displays itself in the modified behaviour of the motor muscles. As a rule their total power is diminished by convex glasses and increased by concave glasses and this independent of the variation in the angle of convergence caused by a displacement of the working point. If now we were dealing with eyes, which were in a physiological state it would be mere waste of time to say that to discover the precise condition of the muscular forces we must see to it, that in testing their power the patient uses his accommodation exactly and accurately for the point of convergence. To attain this end, Hansen insists on the patients looking at a short word, Theobald at a star; Graefe said that if any doubt arise, a short oblique line must be used — and not his fine line traversing a large dot. The facts which I have observed in studying asthenopia lead me to attach less importance to this precaution, than these and other authors do, and than I was formerly inclined to do. I shall bring forward pertinent facts when I speak of the modes of examination in detail and especially when taking into account the condition of accommodation.

We next must inquire if there be any physiological standard for adduction and abduction, what they should in combination amount to, either for the near or for the far, and what should be the ratio between



them. It is certain that great variation must be allowed in this matter, and not only in the totals, but in the capacity of each, and as to the ratio between adduction and abduction there is considerable variety, but there is much greater uniformity in their relations at the far point than at the working point. On this I must lay stress and as a corollary say that much error has arisen from dependence on examination of adduction and abduction at the working point, which would have been avoided, if the far point had been chosen. I have found very few patients in whom abduction at the far point was below  $5^{\circ}$  or  $4^{\circ}$ , who did not suffer from asthenopia. If they did not, adduction at the far point would be low, viz. not more than  $8^{\circ}$  or  $12^{\circ}$ . A certain ratio must be preserved, but I cannot say exactly what it shall be. I am guided both by the existing ratio between adduction and abduction and also by the absolute amount of abduction. It is necessary to teach the patients, what they are expected to do, where they are to look, and they must be stimulated to exert themselves. They must repeat their efforts until they arrive at uniformity in their statements, and this will not be reached until they have labored long enough to become a little fatigued and have brought about that state of their eye muscles which shall nearly correspond to their condition, when they have asthenopic symptoms. On the one hand one must not accept as correct the first statements of a patient, if through lack of experience he evidently gives us results, which are below the truth, nor must we accept his first and energetic effort as an evidence of his condition when his ordinary complaints begin. On the other hand, by prolonged practice the power of adduction and of abduction may be increased, but this fact does not apply in the case of a patient who for the first or third time is being put under examination. When we form a judgement about the condition of a patients muscles we need not be disturbed by knowing, that some persons and especially experts (oculists) sometimes have extraordinary ability for convergence and divergence. Bisinger in one part of his article, page 75, gives the adduction of Dr. Schleich at 6 meters as  $110^{\circ}$ , his abduction as  $13^{\circ}$ , and in the appendix to the same article in another place, page 112, his adduction is put at  $48^{\circ}$ , his abduction at  $13^{\circ}$ . In my own person I can easily reach  $60^{\circ}$  adduction and  $12^{\circ}$  abduction at  $20'$ . I have friends, who can excel me in this respect. In my examinations I rarely trouble myself to go above  $45^{\circ}$  or  $50^{\circ}$  adduction, when I find a patient able to do this, and I do not set them down as deficient in adduction, if they do not go above  $24^{\circ}$ . In abduction it is unusual to find more than  $10^{\circ}$  and the average normal ability is from  $5^{\circ}$  to  $8^{\circ}$ . Abduction below  $5^{\circ}$  calls for attention and is likely to be accompanied with asthenopia. On this matter my examinations have simply been directed to the discovery of the causes of asthenopia and I have never undertaken any studies in an exact way to discover the facts of physiological fusion. Dr. Bisinger under the auspices of Prof. Nagel (Mittheilungen aus der ophthalmiatischen Klinik in Tübingen, 1880) has made the best researches on record in this direction. He has repeated Donders' studies of the relative A, and has also investigated both the relative fusion and the absolute fusion. He found it far more difficult to get trustworthy results of the muscular fusion than of relative accommodation. His studies were confined to six persons, and with some of his conclusions my own deductions do not agree. He however was dealing with physiological conditions, and I have dealt only



with pathological conditions. He says pag. 106, that the range of relative accommodation is much wider than the range of relative fusion: that if relative fusion be compared with absolute fusion, the ratio of the former to the latter is much less than is the case between relative and absolute range of A. He also says that relative fusion is more intimately dependent upon relative A than is relative A upon relative fusion, and that practice is more effective in enlarging the relative accommodation range than the relative fusion range. It is certainly true that the facts which Dr. Bisinger elicited do not correspond to the facts more roughly ascertained which I have found. But as before remarked the subjects with whom I have dealt, have been persons in whom the normal relations between muscular fusion and accommodation have been disturbed, or totally reversed, in other words, they have been asthenopics. To this he refers at the conclusion of his paragraph on page 107.

A valuable contribution to the study of the capacity of adduction and abduction is given by Dr. H. S. Schell in *The American journal of the medical sciences*, Oct. 1878, page 418. He gives one table of 20 emmetropes, whose adductive power at the distance varied from  $28^{\circ}$  to  $44^{\circ}$  and their abductive power varied from  $4^{\circ}$  to  $16^{\circ}$ . The average was adduction  $29^{\circ}$ , abduction  $8\frac{1}{4}^{\circ}$ . The average ratio between them was 100 to 28. He also gives 16 hypermetropics who did not squint, whose adduction at the distance varied between  $14^{\circ}$  and  $38^{\circ}$  and whose abduction between  $7^{\circ}$  and  $15^{\circ}$ . The average was adduction  $25^{\circ}$ , abduction  $12^{\circ}$  and the average ratio between them was 100 to 48.

In my tests for the near point I do not use the spectacle frame but a holder, which somewhat resembles a stereoscope in which prisms can be carried amounting to  $60^{\circ}$ , and in which too the needful glasses for refractive error can be placed. The prisms are always rectangular and for the distant point, two are held in each of my hands and are placed one partly lapping over the other and thus a rapid advance can be made from low degrees say  $3^{\circ}$  up to  $23^{\circ}$  without taking the prisms away from the patients eyes. I usually hold at the outset, in testing distant adduction  $3^{\circ}$  and  $5^{\circ}$  in one hand, and  $5^{\circ}$  and  $10^{\circ}$  in the other hand. When these have been mastered I keep the weak prisms in one hand and in the other take  $10^{\circ}$  and  $15^{\circ}$ . If needful I let the patient hold one prism, which he has been able to easily master. I have some times used the »prisme mobile« of Snellen, made by Nacet. In my notation of cases I adhere to the old system of giving the numbers of glasses by their focal length, rather than by dioptries. It is to me more convenient than the other system, and both are intelligible. I use the letters v. d. to signify vertical diplopia caused by a prism, whose base is held up or down. I also use the sign  $\text{♁}$  to signify equilibrium; it is the astrological symbol of the zodiacal sign of the constellation Libra (the scales).

It remains now in discussing the tests for muscular asthenopia, to take into consideration v. Graefe's famous equilibrium test. Few recent writers have given it unqualified approval. Some have pronounced it valueless; Mannhardt, Mauthner, Loring and Theobald have recorded their objections to it, while Kugel (*Graefes Archives XVIII, N. 173*) praises it abundantly. I shall have to refer again to Dr. Kugel's opinion. Graefe recognised that the fine line might sometimes provoke a tendency to fusive efforts despite the vertical diplopia and in that event he counselled the use of a



short oblique line. But more radical than this is Hansen's objection to the dot even when used alone, that it does not ensure on the part of the patient an exact accommodation. He therefore insists on the use of a short word (see Report of 5th. international ophthalmological congress p. 103 to 125, 1876). Theobald has the same idea. Now in v. Graefes great paper (Zehender Klinische Monatsblätter 1869) he was discussing Myopia and muscular insufficiency. Confessedly in this state of refraction A is often absent and for the special cases of M. which he had in view, it usually was wanting. Therefore Graefe had in that article little occasion to take A into account. But with muscular insufficiency in other states of refraction than M, Graefe was familiar, as various allusions in this article show (see pages 226, 229 and foot note 232), and we must regret that he did not give us his experience with them.

In cases not myopic it is certainly true, that the equilibrium test must be used with corrections and reservations, just as we must make allowances for various disturbing elements in the behaviour of the magnetic needle. It is our business to discover and duly estimate the value of the disturbing conditions and with this precaution the equilibrium test will greatly instruct and assist us in our investigations. To assume however as Graefe did in myopia, that the degree of insufficiency is always correctly expressed and measured by the prism which shall bring the two dots with a vertical line is certainly erroneous both in myopia and in other refractive states. More erroneous is it in the latter than in the former. Moreover Graefe was in the habit of using the equilibrium test for the near rather than for the far point.

I hold with Hansen that it is far more helpful and more trustworthy for the far point than for the working point. Illustrations of this will be given in reporting cases.

If asked how is the degree of insufficiency to be expressed, I reply that one must know at what range whether far or near the inquiry is made; — the near is untrustworthy; the amount at the far point is commonly much less than at the working point — and a small amount there, is more to be regarded than a large degree here. Again the degree of insufficiency is not to be discovered by such a test, because much of the error is for a considerable period latent, despite our efforts to drag it to light. It will sometimes appear that a an original small insufficiency is finally doubled or tripled in amount. In my judgement the degree of insufficiency can rarely be exactly expressed, it will show variations of several degrees at different times, and as above said it must be spoken of with reference to the distance of investigation or in Nagel's language with reference to the metric angle.

It is a quantity which will after due time approximately be indicated by the prisms which at the punctum remotum or punctum agendi will bring the two dots vertically above each other — but the absolute amount of muscularity and the proportions of adduction and abduction to each other must be kept in view at the same time. These two factors do not by any means always maintain corresponding relations; each must be taken for what it is worth and both must be looked at in combination.

This long discussion on the general subject of asthenopia brings me to the topic of insufficiency of the recti externi. These muscles have been honored with scant attention as compared to the recti interni. In Graefe & Saemisch's Handbuch, while we have in vol. VI, 32 pages



given to the latter, only parts of pages 216 and 217 are deemed enough for troubles both of the externi and of all the other muscles which may occasion muscular asthenopia. In his admirable brochure on strabismus, 1881, Schweigger speaks of insufficiency of the externi as being sometimes a cause of convergent strabismus in E and in M (page 25). Doubtless the externi do not play a part so conspicuous in pathology and physiology as do the interni, but I beg to bespeak for them a higher meed of regard than they have hitherto had, because they have enjoyed less honor than their powers for good and ill entitle them to claim.

In a paper published in the report of the 5th. international ophthalmological congress, New-York 1876, I cite 16 cases of insufficiency of the externi among a total of 227 cases of muscular insufficiency. I certainly should now place the proportion much higher. I now offer for study 82 cases of insufficiency of the externi and of them 8 were included in the report above mentioned, the remainder have been noted within 8 years and in private practice. The cases are subdivided in respect to the state of refraction as follows, viz.:

E.	20 cases
M.	13 »
H.	30 »
Astigm.	19 »
	82.

Of the emmetropic cases there were males 16, females 4. Of them 4 were below 20 year of age, the remainder were between 20 and 50 years of age. Of the myopic cases there were males 7, females 6. Below 20 years of age 3 between 20 and 40 years 8, between 40 and 60 years were 2. As to degrees of M. there were:

Equal to or less than	1 D.	=	3 cases
Between	1 and 2 D.	=	1 »
»	2 and 3 D.	=	2 »
»	3 and 4 D.	=	2 »
»	4 and 7 D.	=	1 »
»	7 and 9 D.	=	1 »
»	9 and 12 D.	=	2 »
Anisometropia	O. D. 3,33 D.	}	= 1 »
	O. S. 5,00 D.		
			13 cases.

It appears, that eight cases had M. not greater than = 4 D., and the remainder were between 7 D. and 16 D. Of the 30 hyperopic cases males were 14, females 16. As to age there were below 20 years: 13 cases, between 20 and 40 years: 11 cases; between 40 and 64 years; 6 cases; total = 30.

Degrees of H. were as follows. Atropia was not used in 12 cases, and it was used in 18 cases. Of the 12 cases the Hm. was in all between + 5 D. and + 2 D, Of the 18 cases Ht. was less than + 2 D. in 17 cases and in one case reached + 2,5 D. It is evident then that marked refractive error does not characterise this series of cases.



Of 19 cases of astigmatism males were 10, females 9. In age 5 were below 20 years, 12 between 20 and 40 years, 2 between 40 and 75 years. Of 19 cases of astigmatism in 8 atropia was not used and in 11 it or homatropia was used. In 16 cases the error was less than 2 D. in amount, while in the 3 remaining cases it did not exceed 4 D. in either eye. It is therefore justifiable to say, that refractive error was very low in these cases — with the exception of one case, who had

$$\begin{aligned} \text{O. D.} & - 6s - 42c \ 30^0 \\ \text{O. S.} & - 6s - 36c \ 180^0 \end{aligned}$$

and here the important element was myopia and not astigmatism.

In examining these cases it has been remarked, that for a certain number atropia was employed. This was done for a variety of reasons viz. to show the true state of refraction, as an aid to the diagnosis of the degree and kind of muscular error, to neutralise and remove spasm of accommodation, and finally it was sometimes employed as a means of treatment, after the diagnosis had been settled. It is true, that in many cases the muscular status was taken before employing the mydriatic, and in many cases also while the eyes were under its influence, and again after its effects had disappeared. The indication, which decided in favor of the use of atropine, when the patient would consent to its employment was in the first place severe pain, secondly evidence of spasm of accommodation. The signs of the latter were found in inconsistent and conflicting findings as to the status of the refraction and the capacity of the muscles; in evidence gained by the ophthalmoscope with the upright image and by examining the accommodation with convex abductive prisms. If all these three sources of evidence concurred in favor of spasm of A. atropine was insisted upon. I make use of a combination of convex glasses 12 inches or 33 centimeters focus, with abductive prisms whose degree shall in toto equal  $14^0$  and through these desire the patient to read the smallest capital letters of Snellen 1. I prefer to use the abductive prismatic convex 12 to a simple + 12 because with them the relaxation of visual axes ought also to relax the A., and I wish to give the patient every advantage to show himself innocent of accommodative error. The removal of the metric angle beyond the principal focal point of the convex glasses would amount in a person, whose inter-ocular distance between the centres of motion was 64 mm. to 1,4 metric angles, i. e. to 714 mm. beyond the point of fixation which I generally take at 300 mm. (12" English). The actual place of convergence is then at  $300 + 714 = 1014 \text{ mm.} = 3'4''$  or about 1 M. In some cases, where there was marked tendency to convergence, the prisms were not used and only spherical + 12 employed. With either glasses the patient should read S. 1 at 12". If he did not do this, but only at 10" or 9", spasm of A. was assumed. If the patient needed a correction for ametropia, he was provided with the suitable glass, and if his punctum agendi was at some other point than 12", proper modifications were made. Absolute accuracy was not expected in this mode of testing, but trustworthy clinical facts were sought for.

In resorting to atropia in cases of spasm of A., I am at issue with some most estimable observers who dispute the value of all such observations. They contend, that the facts thus brought to view have no real value. I beg to say in reply, first, that the complete suspension of A. by atropia does not destroy in the converging muscles their impulse to



exertion, because the person knows by the view of the white dot on a black surface, which I use, that convergence is called for; he is aware of its position at 12 inches, and though he does not see it with sharp outline he converges for it. Again I may put before the person a + 12 which enables him to see the dot with almost perfect distinctness, and by it he is able to put forth as much muscular effort as the existence of normal A. would incite him to do. — Finally my aim in the investigation of asthenopia is to examine the functions of the eyes not only in their combination, but apart from each other, and this both at the punctum agendi and at the punctum remotum. It is needful in the case of the punctum agendi to use atropia to put the A. aside, and I may provide the patient with + 12 to enable him to see the dot at 12" well enough to use his ordinary muscular efforts. But I have found in very many cases with paralysed A. that no convex glass was needful to show the muscular power at 12". The answers have over and over again been just the same as to adduction and abduction prisms at 12" whether a convex glass were or were not used with the prisms.

That the accommodation has a powerful influence upon the adduction and abduction I am perfectly aware, and I am not disputing their physiological relations and interdependence. But my contention is that in many cases of asthenopia the accommodation has brought the motor muscles into a pathological condition.

They may be too highly stimulated or they may have become exhausted, and for this reason I in certain cases remove from the muscles this untoward influence to learn if I can, what is their true condition.

These assertions demand proof and I proceed to furnish it. First as to the number of cases, in which I have employed atropine.

			Total.
Atropine was used in emmetropic cases .....	5		
» not used .....		15	20
Atropine used in hyperopic cases .....	19		
» not used .....		11	30
Atropine used in myopic cases .....	5		
» not used .....		8	13
Atropine used in astigmatic cases.....	11		
» not used .....		8	19
	40	42	82

It appears that in one half the cases atropine was employed, and in one half it was not employed. The reason for its non employment must be first discovered. I find the reasons to be as follows:

Diagnosis obvious .....	14	cases
No spasm A .....	8	»
Cases purely reflex and moderate asthenopia...	2	»
No asthenopia.....	1	»
Examination very prolonged.....	1	»
Examination incomplete because patient objected or for other reasons.....	8	»
Noted, that atropine ought to have been used.....	6	»

Total = 40 cases.



Comment on this statement is needless. I turn to the 42 cases, where atropine was employed with the view of aiding in diagnosis and select such cases as were examined as to their muscular status before its employment, during its continuance, and after its effect had passed. Of these many however were not examined in regard to all the details of adduction, abduction and equilibrium test for both near and far.

My object was to learn the facts necessary for practical purposes, and when my mind was convinced on this matter, I often omitted to take other evidence which would be merely confirmatory and not indicative. I can however present the following cases in which the details were worked up and offer them for inspection.

Case IV. Boy aged 9. Emmetropic v. =  $\frac{20}{18}$ . With marked spasm of accommodation, suffering from severe irritation and itching of the conjunctiva and inability to use his eyes:

$$\begin{array}{l} \text{at } 20' \text{ add.} = 10^0 \\ \text{abd.} = 3^0 \\ \text{v. d.} = 2^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 10^0 \\ \text{abd.} = 3^0 \\ \text{v. d.} = 2^0 \text{ conv.} \end{array}} \right\} 13^0 \qquad \begin{array}{l} 12'' \text{ add.} = 20^0 \\ \text{abd.} = 12^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} 12'' \text{ add.} = 20^0 \\ \text{abd.} = 12^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array}} \right\} 32^0$$

During the effect of atropia and without using any glass.

$$\begin{array}{l} 20' \text{ add.} = 15^0 \\ \text{abd.} = 1^0 \\ \text{v. d.} = 7^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} 20' \text{ add.} = 15^0 \\ \text{abd.} = 1^0 \\ \text{v. d.} = 7^0 \text{ conv.} \end{array}} \right\} 16^0 \qquad \begin{array}{l} 12'' \text{ add.} = 20^0 \\ \text{abd.} = 10^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} 12'' \text{ add.} = 20^0 \\ \text{abd.} = 10^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array}} \right\} 30^0$$

The muscular power is seen to be low and something is to be allowed for the boys timidity. It is manifest that atropia which was used in 2 grain solution 3 times daily for four days did not abate in an important degree for the near point his power of adduction and abduction. Its effect on the muscularity at the far point was to reduce the strain on the abduction, to improve the adduction and to show conspicuously by the equilibrium test that the externi were weak and were the factors in causing the spasm of accommodation and the asthenopia.

Case V. Boy aged 9, O. U. E.  $\frac{20}{30}$ . Decided spasm A. Has severe pain in eyes and head, which prevent study. Had eye trouble 4 years. Has photophobia and cannot long fix upon an object whether remote or near.

$$\begin{array}{l} \text{At } 20' \text{ add.} = 3^0 \\ \text{abd.} = 5^0 \end{array} \left. \vphantom{\begin{array}{l} \text{At } 20' \text{ add.} = 3^0 \\ \text{abd.} = 5^0 \end{array}} \right\} 8^0 \qquad \begin{array}{l} \text{At } 12'' \text{ add.} = 15^0 \\ \text{abd.} = 0^0 \\ \text{v. d.} = 15^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{At } 12'' \text{ add.} = 15^0 \\ \text{abd.} = 0^0 \\ \text{v. d.} = 15^0 \text{ div.} \end{array}} \right\} 15^0$$

After using atropia 9 times in 3 days and being brought under its general toxic effects as well as its ocular effects:

During mydriasis

$$\begin{array}{l} \text{at } 20' \text{ add.} = 23^0 \\ \text{abd.} = 5^0 \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 23^0 \\ \text{abd.} = 5^0 \end{array}} \right\} 28^0 \qquad \begin{array}{l} \text{at } 12'' \text{ add.} = 20^0 \\ \text{abd.} = 25^0 \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 20^0 \\ \text{abd.} = 25^0 \end{array}} \right\} 45^0$$

In this cas the low muscularity at the first examination was simply the evidence of inability to fix eyes steadily, and of the photophobia which prevented him from putting forth his real power. Under the relaxing effect of atropia, the muscularity for distance rose or rather asserted itself, while the imperfect record for the near still allows us to see that here too the muscular power was freed from restraint and became better.



Case VI. Girl aged 12 suffered for two years from headache and pain in eyes and other asthenopic symptoms of severe character. Before atropine E., v. =  $20/18$  O. U. Has marked spasm of A.

$$\begin{array}{l} \text{at } 20' \text{ add.} = 20^0 \\ \text{abd.} = 3^0 \\ \text{v. d.} = 3^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 20^0 \\ \text{abd.} = 3^0 \\ \text{v. d.} = 3^0 \text{ conv.} \end{array}} \right\} 23^0 \qquad \begin{array}{l} \text{at } 12'' \text{ add.} = 15^0 \\ \text{abd.} = 12^0 \\ \text{v. d.} = 7^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 15^0 \\ \text{abd.} = 12^0 \\ \text{v. d.} = 7^0 \text{ conv.} \end{array}} \right\} 27^0$$

The very low muscularity at  $12''$  was the results of the great difficulty which she had in fixing her eyes upon a near object.

After using a two grain solution of atropine 6 times in two days the following was found, viz. H.  $1/24$  V =  $20/20$

$$\begin{array}{l} \text{at } 20' \text{ with } + 24s \text{ add.} = 12^0 \\ \text{abd.} = 4^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ with } + 24s \text{ add.} = 12^0 \\ \text{abd.} = 4^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array}} \right\} 16^0 \qquad \begin{array}{l} \text{at } 12'' \text{ with } + 24s \text{ add.} = 25^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 8^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ with } + 24s \text{ add.} = 25^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 8^0 \text{ conv.} \end{array}} \right\} 30^0$$

After a week longer and with continuance of atropia the findings remained nearly the same.

The effect of atropine on the muscularity at the far point was unimportant, because in the trial during mydriasis the  $+ 24s$  was used and under its influence the muscular exertion was naturally abated. But for the near point also despite the abating influence of the  $+ 24s$  adduction and abduction changed in favor of the adduction, which is contrary to the usual physiological law. The evident explanation is, that the externi, which had hitherto been under great tension, were now released and the state of repose was being assumed.

Case VII. Female aged 38. E. v. =  $20/20$ . Has no spasm A. Before using atropine the condition was as follows:

$$\begin{array}{l} \text{at } 20' \text{ add.} = 20^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 1^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 20^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 1^0 \text{ conv.} \end{array}} \right\} 25^0 \qquad \begin{array}{l} \text{at } 12'' \text{ add.} = 35^0 \\ \text{abd.} = 25^0 \\ \text{v. d.} = \text{—} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 35^0 \\ \text{abd.} = 25^0 \\ \text{v. d.} = \text{—} \end{array}} \right\} 60^0$$

After using atropia 14 times within 6 days found H. =  $1/48$  v. =  $20/20$  O. U. and during its influence

$$\begin{array}{l} \text{at } 20' \text{ add.} = 25^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 1^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 25^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 1^0 \text{ conv.} \end{array}} \right\} 30^0 \qquad \begin{array}{l} \text{at } 12'' \text{ add.} = 20^0 \\ \text{abd.} = 25^0 \\ \text{v. d.} = 7^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 20^0 \\ \text{abd.} = 25^0 \\ \text{v. d.} = 7^0 \text{ conv.} \end{array}} \right\} 45^0$$

It was also noted that when the want of A. was corrected by giving the patient  $+ 14s$  for the test at  $12''$  the muscular findings were precisely the same. This of course did not enable the patient to use any power of A. and the influence of the ciliary muscle on convergence was therefore as much out of question as without the  $+ 14s$ : but it does show that sharp definition of the object is not necessarily essential to the functional capacity of the motor muscles. At this time the atropine had not fully removed pain and it was continued for 6 days longer and the patient was also made to wear adductive prisms of  $2^0$  each (that is with bases outwards) all the time. This completely relieved pain and brought about the state of repose and improved greatly the muscular power. The findings were as follows:

$$\begin{array}{l} \text{at } 20' \text{ add.} = 32^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 32^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array}} \right\} 37^0 \qquad \begin{array}{l} \text{at } 12'' \text{ add.} = 60^0 \\ \text{abd.} = 15^0 \\ \text{v. d.} = 6^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 60^0 \\ \text{abd.} = 15^0 \\ \text{v. d.} = 6^0 \text{ conv.} \end{array}} \right\} 75^0$$



The second finding with atropine exhibits a much greater effect than did the first finding because it was clear that the neuralgic conditions had not been relieved, and when this was accomplished by the joint effect of atropia and adductive prisms the muscular energy positively increased at both ends of the range of fusion. At the same time the relation between adduction and abduction at the punctum agendi underwent a very notable transformation.

Case VIII. Male aged 34, Mr. R. an editor had had asthenopic symptoms for 20 years and had used glasses very much for its relief. There was no spasm of A.

$$\text{O. D.} + 48\text{s v.} = \frac{20}{18}$$

$$\text{O. S.} + 36\text{s v.} = \frac{20}{18}$$

$$\text{at } 20' \text{ with } \left\{ \begin{array}{l} \text{add.} = 34^0 \\ \text{abd.} = 2^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array} \right\} 36^0$$

$$\text{at } 12'' \text{ with } \left\{ \begin{array}{l} \text{add.} = 24^0 \\ \text{abd.} = 11^0 \\ \text{v. d.} = 11^0 \text{ div.} \end{array} \right\} 35^0$$

Curiously enough the total muscularity for the far point and for the near point are the same. This is contrary to the usual fact, and I am aware that Bisinger says, that such is the usual fact, but to this statement I do not subscribe. Again it is seen, that the equilibrium test (v. d.) gives convergence for distance and divergence for the near, and the patient had slight hypermetropia.

Under the influence of atropia, which was carried to full effect, the refraction became

$$\text{O. D.} + 60\text{s} + 60\text{c } 90^0 \text{ v.} = \frac{20}{18}$$

$$\text{O. S.} + 36\text{s} + 92\text{c } 85^0 \text{ v.} = \frac{20}{18}$$

During this time.

$$\text{at } 20' \text{ with } \left\{ \begin{array}{l} \text{add.} = 40^0 \\ \text{abd.} = 2^0 \\ \text{v. d.} = \text{—} \end{array} \right\} 42^0$$

$$\text{at } 12'' \text{ with } \left\{ \begin{array}{l} \text{add.} = 40^0 \\ \text{abd.} = 22^0 \\ \text{v. d.} = 12^0 \text{ div.} \end{array} \right\} 62^0$$

Immediately after the effect of atropia had passed away, the condition was

$$\text{at } 20' \text{ add.} = 40^0 \left\{ \begin{array}{l} \text{abd.} = 2^0 \\ \text{v. d.} = \text{—} \end{array} \right\} 42^0$$

$$\text{at } 12'' \text{ add.} = 48^0 \left\{ \begin{array}{l} \text{abd.} = 23^0 \\ \text{v. d.} = \text{—} \end{array} \right\} 71^0$$

The patient had been using adductive prisms of  $2^0$  each for constant wear, besides the atropia, and the effect of both combined was to induce the condition of repose, and when this was attained, the total muscularity rose, and that for the near point rose in a most remarkable degree. The additional and most notable point, which astonished me, was that under this treatment the state of divergence with vertical diplopia at the working point ultimately gave place not only to equilibrium, but that this became the state of repose. Reference will be made to this again. It is clear, that atropia in this case had no repressing influence on the activity of the muscles at the working point.

Case IX. A woman, aged 44, with spasm of A and H.  $\frac{1}{36}$  v. =  $\frac{20}{20}$  O. U. has had headache and eye trouble for four years and these have been severe for four months. She uses + 12s in reading.



$$\text{at } 20' \text{ add.} = 30^0 \left. \vphantom{\text{at } 20'} \right\} 37^0 \\ \text{abd.} = 7^0$$

$$\text{at } 12'' \text{ with } + 12'' \text{ add.} = 30^0 \left. \vphantom{\text{at } 12''} \right\} 55^0 \\ \text{abd.} = 25^0 \\ \text{v. d.} = 3^0 \text{ div.}$$

Under atropia she exhibited H.  $\frac{1}{24}$  v. =  $\frac{20}{20}$  and had

$$\text{at } 20' \text{ with } \left. \vphantom{\text{at } 20'} \right\} 21^0 \\ + 24\text{s} \quad \left\{ \begin{array}{l} \text{add.} = 15^0 \\ \text{abd.} = 6^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array} \right.$$

$$\text{at } 12'' \text{ with } \left. \vphantom{\text{at } 12''} \right\} 70^0 \\ + 24\text{s} \quad \left\{ \begin{array}{l} \text{add.} = 55^0 \\ \text{abd.} = 15^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array} \right.$$

The same finding was obtained without + 24s at 12''.

When the effects of atropia had disappeared, the situation was

$$\text{at } 20' \text{ with } \left. \vphantom{\text{at } 20'} \right\} 28^0 \\ + 36\text{s} \quad \left\{ \begin{array}{l} \text{add.} = 28^0 \\ \text{abd.} = 0^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array} \right.$$

$$\text{at } 12'' \text{ with } \left. \vphantom{\text{at } 12''} \right\} 70^0 \\ + 36\text{s} \quad \left\{ \begin{array}{l} \text{add.} = 58^0 \\ \text{abd.} = 12^0 \\ \text{v. d.} = 15^0 \text{ conv.} \end{array} \right.$$

Here the effect of + glasses in restraining muscular effort at the distance is displayed, while for the near the total muscularity rises under the effect of atropia independently of the employment of glasses.

Case X. Young lady, aged 14, with moderate spasm of A. has E. v. =  $\frac{20}{18}$  O. U. Has had, as she says, fearful headache and pain in her eyes. I found

$$\text{at } 20' \text{ add.} = 30^0 \left. \vphantom{\text{at } 20'} \right\} 35^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = \text{—}$$

$$\text{at } 11'' \text{ add.} = 35^0 \left. \vphantom{\text{at } 11''} \right\} 50^0 \\ \text{abd.} = 15^0 \\ \text{v. d.} = \text{—}$$

After using a two grain solution of atropine 9 times in 3 days, the condition was

$$\text{O. D. } + 60\text{c } 90^0 \text{ v.} = \frac{20}{30} \\ \text{O. S. } + 60\text{c } 90^0 \text{ v.} = \frac{20}{30}.$$

$$\text{at } 20' \text{ add.} = 23^0 \left. \vphantom{\text{at } 20'} \right\} 28^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 3^0 \text{ conv.}$$

$$\text{at } 12'' \text{ add.} = 30^0 \left. \vphantom{\text{at } 12''} \right\} 45^0 \\ \text{abd.} = 15^0 \\ \text{v. d.} = \text{—}$$

This case shows a degree of reduction of muscular power for both ends of the fusion range under the effect of atropine, but not any more for the near than for the far.

These seven cases from IV to X inclusive seem to me conclusively to demonstrate not only the value of atropia in some cases as a therapeutic agent, but what is of vast consequence in our studies, is, it does not nullify the usual activity of the muscles. They perform their duty when called upon to direct the visual axes to a near point in very much the same way that a physiological pair of eyes would do without atropine. I make the point that for these cases such behaviour is probably exceptional, and that it is part of the essence of the asthenopic condition. The nearness of the object is enough to stimulate the muscles to the act of convergence without the cooperation of the accommodation. What would happen in non asthenopic eyes under the effects of atropine is a subject worthy of investigation.

That spasm of A. was not the only hurtful element in these cases I am well aware: the severe neuralgia, which belongs to asthenopia, was another factor, and against both this and the former, atropia is an antidote.



Combine with this the compulsory rest, which mydriasis causes, and I think we have enough to account for the benefit of the proceeding.

This long discussion has been held upon the effects of atropia in these cases, because it touches a point vital to the pathology of asthenopia, and it stands in apparent contradiction to established facts in physiology. I am not bound to reconcile discrepancies between pathology and physiology; it were logical to expect to find them. I have found the above facts and know them to have been carefully observed. I have had no theories to maintain, and leave all theory for future consideration.

At length it becomes possible to take up in particular the special features of insufficiency of the external recti muscles. I have anticipated in the narration of the preceding eight cases the mode in which I study cases of asthenopia and now I beg to indicate on what grounds I place the diagnosis of fault of the recti externi.

It is not true these cases always reveal themselves readily as belonging to this category. On the contrary, while some are very plain others are masked and may so remain for some time, and others may present contradictory symptoms. First let us take up the cases in which the symptoms are from the outset clearly distinctive and upon which no one would hold any discussion.

Of the total 82 cases, I may make the following general classification in this particular:

Class I. Cases in which the symptoms were similar or not contradictory for the far and for the near	E.	H.	M.	Astg.	Total.
	18	22	10	13	63
Class II. Cases in which the symptoms were contradictory for the far and for the near	1	4	3	6	14
Class III. Cases in which the true condition was at first concealed	8	4	0	1	5
					82

In about 77% of the cases the symptoms for the near and for the far were consistent. By this I mean that the equilibrium test exhibited dynamic convergence in both regions, or that if it showed equilibrium at the far point it showed dynamic convergence at the near point. In cases in which this test was not used at both extremities, a very low abduction at 20' is accepted as the equivalent, and by very low I mean abduction of 5° or less. Combined with this there would also be low abduction for the near, but a positive limit cannot be stated.

So too if, as was shown in a few cases, there was dynamic convergence at 20' and equilibrium at the near, this ultimately proved to have dynamic convergence at both extremities, but abduction at 20' was only 4° and this was regarded as enough to render the diagnosis highly probable. In another case at 12" with + 24 s v. d. =  $\infty$ , but at 20' abduct. = 3°. In this case there could be no doubt.

It is seen that my diagnosis is founded upon the respective degrees of adduction and abduction, upon their ratio to each other and upon the equilibrium test, and all to be taken at both ends of the range of fusion. For very many cases other tests were helpful, viz, the tremor of the globes when moved to the outer angles of the palpebral slit; sometimes there was diplopia in these positions. Frequently in these cases when



one eye was screened and the other fixed on a point 3" distant, the concealed eye went into divergence. This point was noted in a great many cases and has no serious diagnostic meaning.

It is not necessary to discuss the symptoms of these cases in detail or to quote any of them. All that is interesting about them will be stated under the head of treatment.

I turn to the cases in which the symptoms at the extremities of the range of fusion were contradictory, viz.

Class II. I begin with that one, which first forcibly attracted my attention and whose peculiarities have given me some new conceptions on insufficiency of the external recti. It has already been referred to under another head and has been numbered as

Case VIII. Mr. R. aged 34. Editor came to me March 3, 1884. He had suffered from chronic blepharitis and other asthenopic symptoms for 20 years. He had worn glasses prescribed by oculists and yet was far from being well. Without using atropine his refraction was

$$\begin{aligned} \text{O. D.} + 48\text{s v.} &= \frac{20}{18} \\ \text{O. S.} + 36\text{s v.} &= \frac{20}{18}. \end{aligned}$$

He had no spasm of A.

His muscles showed

$$\begin{array}{l} \text{at } 20' \text{ add.} = 30^0 \\ \text{abd.} = 4^0 \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 30^0 \\ \text{abd.} = 4^0 \end{array}} \right\} 34^0 \qquad \begin{array}{l} \text{at } 12'' \text{ with } + 48\text{s v. d.} = 12^0 \text{ div.} \\ \text{at } 12'' \text{ no glass v. d.} = 12^0 \text{ div.} \\ \text{at } 6'' \text{ with } + 48\text{s v. d.} = 35^0 \text{ div.} \end{array}$$

When he fixed upon my finger at 3" and one eye was covered, the latter turned very far outward. He had tried abductive prisms in reading to no profit. Being struck by the feeble abduction at 20' I ventured to propose the continuous wearing of adductive prisms. By the ophthalmoscope I estimated refraction

$$\begin{aligned} \text{O. D.} + 2 \text{ D.} \\ \text{O. S.} + 2,5 \text{ D.} \end{aligned}$$

The optic nerves were intensely injected.

I ordered + 48s  $\ominus$  2° prism, base outwards O. U. After wearing these for a week he reported that he had had a notable degree of comfort from them. I found

$$\begin{array}{l} \text{at } 20' \text{ with } + 48\text{s} \end{array} \left\{ \begin{array}{l} \text{add.} = 34^0 \\ \text{abd.} = 2^0 \\ \text{v. d.} = \text{---} \end{array} \right\} 36^0 \qquad \begin{array}{l} \text{at } 12'' \text{ with } + 48\text{s} \end{array} \left\{ \begin{array}{l} \text{add.} = 24^0 \\ \text{abd.} = 11^0 \\ \text{v. d.} = 11^0 \text{ div.} \end{array} \right\} 35^0$$

I then proposed to him to add to the convex adductive prisms + 40s for use in reading. These were useful to him, and a month later I gave atropine and found the refraction to be.

$$\begin{aligned} \text{O. D.} + 60\text{s} + 60\text{c } 90^0 \text{ v.} &= \frac{20}{18} \\ \text{O. S.} + 22\text{s} \text{ v.} &= \frac{20}{18}. \end{aligned}$$

While using atropine he showed

$$\begin{array}{l} \text{at } 20' \text{ with these glasses:} \end{array} \left\{ \begin{array}{l} \text{add.} = 40^0 \\ \text{abd.} = 2^0 \\ \text{v. d.} = \text{---} \end{array} \right\} 42^0$$



at 12" with these glasses: add. =  $40^0$  }  
 abd. =  $22^0$  }  $62^0$   
 v. d. =  $12^0$  div.

There had been steady improvement in muscularity, more for the near than for the far, but the equilibrium test showed divergence for the near.

In May 1884 I found:

at 20' add. =  $45^0$  }  $47^0$   
 abd. =  $2^0$  }  
 at 12" add. =  $50^0$  }  $73^0$   
 abd. =  $23^0$  }  
 v. d. =  $5^0$  div.

He now used + 20s added to the distance glasses in reading. A very remarkable degree of comfort and ability for eye work had now been gained, more than he had ever known, and he was exceedingly pleased. I noted the steady abatement in abduction for distance and also the abatement in the divergence with the equilibrium test for the near. Evidently the status of repose was being attained and with it the overworked recti interni as well as recti externi were beginning to enjoy normal functions. The attitude of the muscles seemed contradictory, but of the improvement in function there was no doubt.

Case XI. Miss K. aged 17, of scrofulous constitution and suffering severely from nasal catarrh, has had asthenopic symptoms for a year, has great spasm of A. vision apparently E. v. =  $20/16$ , at 14" v. d. =  $5^0$  div., at the first visit no other test was employed because evidently spasm of accommodation was extreme. Atropine was directed. After a week the condition was H.  $1/24$  v. =  $20/20$  O. U., the atropine having been used 20 times. She was directed to wear + 36s O. U. constantly. A month from the first examination the situation was as follows, + 36s v. =  $20/16$  O. U., no spasm of A.

at 20' with + 36s add. =  $30^0$  }  $35^0$   
 abd. =  $5^0$  }  
 v. d. =  $2^0$  conv. at 14" + 36s v. d. =  $\infty$

After another month there was

at 14" with + 36s v. d. =  $1^0$  to  $4^0$  conv.

The case was really one of weak externi, resulting in spasm of A. and severe pain. As a result of this condition the interni began to show exhaustion as indicated by divergence under the equilibrium test at 14". Rest and atropia combined relieved this condition and then the contradiction between the far point and the near point of fusion disappeared, — and the real weakness of the externi became obvious over the whole range.

Case XII. Mr. C., aged 64, living in Canada, came in June 1883 with complaint of asthenopic symptoms for a year. Has angina pectoris, for which he sometimes finds relief by using nitro-glycerine. He cannot read at any time longer than an hour and sometimes for only 5 minutes. Has usually troublesome chronic palpebral conjunctivitis. Has E. v. =  $20/20$  A slight degree of spasm of A.

at 20' add. =  $13^0$  }  $18^0$   
 abd. =  $5^0$  }  
 v. d. =  $\infty$  at 12" with + 12s v. d. =  $12^0$  div.  
 at 6" with + 12s v. d. =  $28^0$  div.  
 He uses + 12s in reading.



Advised the use in reading of  $+ 12s \ominus 2^{\circ}$  prism base inward O. U. This prescription was based upon the insufficiency of the interni for the near. With one eye covered and the other fixing on the finger at 3 inches, the concealed eye deviated very far in divergence. After three months the condition was

$$\begin{array}{ll} \text{at } 20' \text{ add.} = 12^{\circ} \text{ to } 18^{\circ} & \text{at } 14'' \text{ with } + 14s \\ \text{abd.} = 5^{\circ} & \text{v. d.} = 9^{\circ} \text{ div.} \\ \text{v. d.} = \text{—} & \end{array}$$

He was now directed to use prisms  $2^{\circ}$  bases inwards continuously and to practice with gymnastic prisms. Up to this time the view which I took of the case was, that while all the muscles were weak the predominant weakness was in the interni as evidenced by the equilibrium test for the near. My aim was to rest the interni and also to give strength to the other muscles by regulated exercise. In this construction of the facts of the case I was certainly adopting what would usually be conceived to be the correct interpretation, but the sequel proved my error. After nine months pursuance of the means prescribed, he reported that he could sometimes wear the abductive prisms for distance and then again could not. Sometimes they seemed helpful and again he could not endure them. No marked value was to be attached to them. He had persevered in the daily use of the gymnastic prisms. His condition was

$$\begin{array}{ll} \text{at } 20' \text{ add.} = 25^{\circ} \left. \begin{array}{l} \text{abd.} = 5^{\circ} \\ \text{v. d.} = 2\frac{1}{2}^{\circ} \text{ conv.} \end{array} \right\} 30^{\circ} & \text{at } 12'' \text{ with } \left. \begin{array}{l} \text{add.} = 10^{\circ} \\ \text{abd.} = 20^{\circ} \\ \text{v. d.} = 10^{\circ} \text{ div.} \end{array} \right\} 30^{\circ} \\ & + 12s \\ & \text{at } 12'' \text{ add.} = 20^{\circ} \left. \begin{array}{l} \text{abd.} = 15^{\circ} \\ \text{v. d.} = 7^{\circ} \text{ div.} \end{array} \right\} 35^{\circ} \end{array}$$

These figures show an increase in total muscularity for distance, but none of the gain is to be credited to the externi. For the near there is still weakness of adduction. A point to be noted for the near is that with the glass correcting presbyopia, the effort of the interni is much abated as usually follows, while the total muscularity remains nearly the same both with and without the convex 12s. At this time I made an examination of the periphery of the visual fields to see whether there would be found any limitation as had recently been declared to be the fact in cases of asthenopia with extreme retinal sensitiveness. See article by Wilbrand in Archives for Ophthalmology vol. XII, pag. 428, 1883. »Neurasthenic asthenopia, and so called anaesthesia retinae.« There was not the slightest degree of limitation of the field, either in dim or in bright light and when using a test object 5 centimetre square. I made the same examination in some other cases and have not yet found the condition which Wilbrand describes.

I now determined to adopt a different plan in treating Mr. C., because I perceived how the abduction lagged behind the adduction and gave him for constant wear prisms  $1\frac{1}{2}^{\circ}$  bases outwards O. U. In two days the condition was

$$\begin{array}{ll} \text{at } 20' \text{ add.} = 23^{\circ} \text{ to } 30^{\circ} \left. \begin{array}{l} \text{abd.} = 4^{\circ} \\ \text{v. d.} = 3^{\circ} \text{ conv.} \end{array} \right\} \begin{array}{l} 27^{\circ} \\ 34^{\circ} \end{array} & \text{at } 12'' + 12s \text{ add.} = 16^{\circ} \left. \begin{array}{l} \text{abd.} = 17^{\circ} \\ \text{v. d.} = 8^{\circ} \text{ div.} \end{array} \right\} 33^{\circ} \end{array}$$



$$\begin{array}{l} \text{at } 12'' \text{ add.} = 33^0 \\ \text{abd.} = 9^0 \\ \text{v. d.} = \underline{\quad} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 33^0 \\ \text{abd.} = 9^0 \\ \text{v. d.} = \underline{\quad} \end{array}} \right\} 42^0$$

Here was encouraging improvement, and after two days longer the condition was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 35^0 \\ \text{abd.} = 4^0 \\ \text{v. d.} = 5^0 \text{ con.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 35^0 \\ \text{abd.} = 4^0 \\ \text{v. d.} = 5^0 \text{ con.} \end{array}} \right\} 39^0 \qquad \begin{array}{l} \text{at } 12'' \text{ with } + 12s \text{ add.} = 12^0 \\ \text{abd.} = 16^0 \\ \text{v. d.} = 9^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ with } + 12s \text{ add.} = 12^0 \\ \text{abd.} = 16^0 \\ \text{v. d.} = 9^0 \text{ div.} \end{array}} \right\} 28^0$$

$$\begin{array}{l} \text{at } 12'' \text{ add.} = 30^0 \\ \text{abd.} = 12^0 \\ \text{v. d.} = 5^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 30^0 \\ \text{abd.} = 12^0 \\ \text{v. d.} = 5^0 \text{ div.} \end{array}} \right\} 42^0$$

He had enjoyed extreme comfort during the use of the adductive prisms. His neuralgic pain had disappeared. His eyes had much less of the usual fatigue, and he could use them with less effort and weariness than before. He was confident of the value of the new arrangement. This accorded with the gain in muscularity both for the far and near, and evidently he was now taking up the position of repose of his visual axes. I advised the continuous use of his adductive prisms for distance and to still employ the convex abductive prisms in reading.

Case XIII. A boy, aged 9, whose asthenopic troubles were severe and who to all usual tests evidenced insufficiency of the interni, came to me in Oct. 1881. After he had had atropia and gained some benefit in the control of his muscles, their situation was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 23^0 \\ \text{abd.} = 8^0 \\ \text{v. d.} = \underline{\quad} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 23^0 \\ \text{abd.} = 8^0 \\ \text{v. d.} = \underline{\quad} \end{array}} \right\} 31^0 \qquad \begin{array}{l} \text{at } 12'' \text{ add.} = 20^0 \\ \text{abd.} = 25^0 \\ \text{v. d.} = 8^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 20^0 \\ \text{abd.} = 25^0 \\ \text{v. d.} = 8^0 \text{ div.} \end{array}} \right\} 45^0$$

He readily exhibited divergence when fixing a near point, and often had crossed diplopia in reading. Has lacrymal and nasal catarrh for which he was treated for several months. The condition was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 16^0 \\ \text{abd.} = 4^0 \\ \text{v. d.} = 4^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 16^0 \\ \text{abd.} = 4^0 \\ \text{v. d.} = 4^0 \text{ div.} \end{array}} \right\} 20^0$$

He holds his book in reading at 9'' distance and at 9'' v. d. = 12<sup>o</sup> div. He was ordered + 6os 3<sup>o</sup> prism base inward for reading. From Febr. 1 to May 16 1882 he used the glasses as much as he could in reading and never more than 10 minutes at a time, frequently not so long. It had been noted that from the first he had the ability to overcome at 20' a prism of 5<sup>o</sup>, and at 14'' he could overcome 10<sup>o</sup>, with base vertical. This was another feature in the looseness of the relations of his muscles in coordination. After 8 months longer his condition was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 19^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 4^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 19^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 4^0 \text{ div.} \end{array}} \right\} 24^0$$

He was now instructed to use gymnastic prisms both for adduction and abduction.



In Febr. 1883, viz, after  $2\frac{1}{2}$  months longer the condition was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 25^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = \text{—} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 25^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = \text{—} \end{array}} \right\} 30^0 \qquad \text{at } 14'' \text{ v. d.} = 5^0 \text{ div.}$$

It was now noted that when his eyes turned to the extreme outer canthi he had homonymous diplopia i. e., in these positions the externi showed great weakness. He kept up the gymnastic prisms and after 7 months longer the condition was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 32^0 \\ \text{abd.} = 6^0 \\ \text{v. d.} = 4^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 32^0 \\ \text{abd.} = 6^0 \\ \text{v. d.} = 4^0 \text{ div.} \end{array}} \right\} 38^0 \qquad \text{at } 12'' \text{ v. d.} = 3^0 \text{ div.}$$

After another period of 6 months, viz in May 1884, he was able to use his eyes an hour at a time 3 times daily. Has no more headache. The condition was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 40^0 \\ \text{abd.} = 6^0 \\ \text{v. d.} = 3^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 40^0 \\ \text{abd.} = 6^0 \\ \text{v. d.} = 3^0 \text{ div.} \end{array}} \right\} 46^0 \qquad \begin{array}{l} \text{at } 12'' \text{ add.} = 55^0 \\ \text{abd.} = 16^0 \\ \text{v. d.} = 3^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 55^0 \\ \text{abd.} = 16^0 \\ \text{v. d.} = 3^0 \text{ div.} \end{array}} \right\} 71^0$$

Up to this time there had been an improvement, and the case seemed to be one of weakness of all muscles but chiefly, as I thought, and as seemed obvious, of the interni. But on going over the history the one persistent fact was the feeble abduction both for far and near. The adduction had notably improved in both regions, but the abduction did not advance. Moreover the equilibrium test indicated feeble adduction both for far and near. I now determined to give credence to the figures of abduction as being the significant symptom. The result proved that their witness was far more worthy of acceptance than that furnished by the equilibrium test. I ordered prisms  $2^0$  base out ward for constant wear. These were used for 4 weeks and the figures became as follows,

$$\begin{array}{l} \text{at } 20^0 \text{ add.} = 40^0 \\ \text{abd.} = 3\frac{1}{2}^0 \\ \text{v. d.} = 1^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20^0 \text{ add.} = 40^0 \\ \text{abd.} = 3\frac{1}{2}^0 \\ \text{v. d.} = 1^0 \text{ div.} \end{array}} \right\} 43\frac{1}{2}^0 \qquad \begin{array}{l} \text{at } 12'' \text{ add.} = 60^0 \\ \text{abd.} = 15^0 \\ \text{v. d.} = 2^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 60^0 \\ \text{abd.} = 15^0 \\ \text{v. d.} = 2^0 \text{ div.} \end{array}} \right\} 75^0$$

$$\begin{array}{l} \text{at } 12'' + 36s \text{ add.} = 40^0 \\ \text{abd.} = 20^0 \\ \text{v. d.} = 5^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' + 36s \text{ add.} = 40^0 \\ \text{abd.} = 20^0 \\ \text{v. d.} = 5^0 \text{ div.} \end{array}} \right\} 60^0$$

Has had great comfort in wearing adductive prisms; he uses them both for near and for distance. He is entirely certain that by them he gets much benefit. He was ordered to add to them  $+ 36s$  in reading as the figures show that with them he has a better balance of muscles than without them. He reads no longer at  $9''$  but at  $14''$ . This case completely convinced me of the fallacious character of the equilibrium test. The results which it indicated were in one sense facts, but these facts in my judgement were not primary but secondary. The divergence for distance as well as for near did not mean that the original trouble belonged to the interni, but that the interni came to be at fault through exhaustion and the original error belonged to the externi. I succeeded in improving the power of the interni and the patient steadily improved, but



he did not reach his true state of repose until I had taken the strain from his externi by the adductive prisms. The case of Mr. Root, Nr. VIII, and the case of Mr. Craig, Nr. XII, proved to me conclusively that the equilibrium test at the near shows a state of facts which are not to be trusted as a diagnosis. The insufficiency of the interni for the near was in them secondary and symptomatic not primary and essential. Now in case V, Jones, I learned that the same condition may be carried to the distant end of the fusion range and that even there by the equilibrium test we must not be led into error. On the other hand the condition of abduction, which was always low, and the homonymous diplopia when the eyes were turned far to the outer canthi gave the key to the situation.

Case XIV. Miss K., aged 44, came to me in 1874 and was fitted with glasses for mixed astigmatism with prevalent myopia. She used them with comfort and had no further eye trouble until March 1884. During the immediately preceding months her health had been impaired by bereavement and attendance upon a sick relative. With her glasses v. =  $20/30$  +. As she had become presbyopic a suitable change was made in her glasses to enable her to read. She however complained that with them and also without them her eyes became weary. She had spasm of A. and upon fixation at 3" there was marked divergence. With her glasses

$$\begin{array}{l} \text{at } 20' \text{ add.} = 20^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 3^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 20^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 3^0 \text{ div.} \end{array}} \right\} 25^0 \qquad \begin{array}{l} \text{at } 12'' \text{ with add.} = 27^0 \\ \text{glasses abd.} = 17^0 \\ \text{v. d.} = 5^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ with add.} = 27^0 \\ \text{glasses abd.} = 17^0 \\ \text{v. d.} = 5^0 \text{ div.} \end{array}} \right\} 44^0$$

She was directed to use gymnastic prisms for adduction and abduction. After 12 days the condition was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 30^0 \\ \text{abd.} = 6^0 \\ \text{v. d.} = \text{—} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 30^0 \\ \text{abd.} = 6^0 \\ \text{v. d.} = \text{—} \end{array}} \right\} 36^0 \qquad \begin{array}{l} \text{with her reading glasses at } 12'' \text{ add.} = 40^0 \\ \text{abd.} = 12^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{with her reading glasses at } 12'' \text{ add.} = 40^0 \\ \text{abd.} = 12^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array}} \right\} 52^0$$

After 16 days longer the situation was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 40^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = \text{—} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 40^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = \text{—} \end{array}} \right\} 45^0 \qquad \begin{array}{l} \text{at } 12'' \text{ with glasses add.} = 45^0 \\ \text{abd.} = 14^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ with glasses add.} = 45^0 \\ \text{abd.} = 14^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array}} \right\} 59^0$$

No other glasses were ordered, and her condition was not yet perfectly satisfactory, but the facts elicited were the same in kind with those of case V just previously narrated: to the effect that the findings of the equilibrium test may not point out a correct diagnosis, but may only show secondary results, and again that the valuable factor in the case is the degree of abduction and its behavior in respect to the adduction.

Case XV. Mr. H., aged 24, was provided with glasses in Nov. 1882 for simple hyperopic astigmatism. He used them with satisfaction until Oct. 1883, when he again complained of trouble and the finding was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 23^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = \text{—} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 23^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = \text{—} \end{array}} \right\} 28^0 \qquad \text{at } 14'' \text{ v. d.} = 5^0 \text{ div.}$$

He was provided with  $\frac{1}{2}$  + 48c 90° ◊ 2° prism base outward O. U.



At first he had difficulty in wearing these glasses, but soon became accustomed to them. He used them for all purposes both reading and at a distance and in 6 months later, April 1884, he had

$$\begin{array}{l} \text{at } 20' \text{ with } + 48c \ 90^0 \text{ add.} = 56^0 \\ \text{abd.} = 1^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ with } + 48c \ 90^0 \text{ add.} = 56^0 \\ \text{abd.} = 1^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array}} \right\} 37^0 \quad \begin{array}{l} \text{at } 12'' + 48c \ 90^0 \text{ add.} = 24^0 \\ \text{abd.} = 19^0 \\ \text{v. d.} = 1^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' + 48c \ 90^0 \text{ add.} = 24^0 \\ \text{abd.} = 19^0 \\ \text{v. d.} = 1^0 \text{ conv.} \end{array}} \right\} 43^0$$

In June 1884 with glasses correcting astigmatism the condition was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 55^0 \\ \text{abd.} = 4^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 55^0 \\ \text{abd.} = 4^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array}} \right\} 59^0 \quad \begin{array}{l} \text{at } 12'' \text{ add.} = 50^0 \\ \text{abd.} = 21^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 50^0 \\ \text{abd.} = 21^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array}} \right\} 71^0$$

He had been using gymnastic prisms for 2 months. The case illustrates again the remarks made under case XX: the discrepancy between near and far not being extreme.

Case XVI. Mr. J., lawyer, aged 22, came to me in Oct. 1876. He had slight hyperopic astigmatism which was determined without atropine, and his muscular condition was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 26^0 \\ \text{abd.} = 3^0 \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 26^0 \\ \text{abd.} = 3^0 \end{array}} \right\} 29^0 \quad \begin{array}{l} \text{at } 14'' \text{ \& glasses add.} = 18^0 \\ \text{abd.} = 27^0 \\ \text{v. d.} = 15^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 14'' \text{ \& glasses add.} = 18^0 \\ \text{abd.} = 27^0 \\ \text{v. d.} = 15^0 \text{ div.} \end{array}} \right\} 45^0$$

It was found, that with a red glass he had homonymous diplopia at 20' and that the images separated still more as the candle was carried to the lateral (temporal) regions. Hence the externi were regarded as faulty. He was ordered gymnastic prisms for adduction and abduction. He did not remain under observation but went to his home in San Francisco. By letter I learned that his eyes continued to trouble him up to Feb. 1877. Since then I have not heard from him. At that time I was unable to understand this case. But I now regard it as a striking illustration of the facts now being presented and as a paralel to Mr. Root, case VIII.

I do not doubt that by atropine and the subsequent use of adductive prisms combined with cylinders he would have reached the status of repose and been enabled in no long time to use his eyes.

Case XVII. Mr. L., aged 30, came to me in November 1883. He had been under the care of an oculist who had prescribed for him concave cylinders:

$$\begin{array}{l} \text{O. D.} - 30c \ 180^0 \ 20/20 \\ \text{O. S.} - 20c \ 180^0 \ 20/20. \end{array}$$

These glasses were correct, and besides them he had been directed to use gymnastic prisms. His muscular asthenopia had been recognised by other oculists, some of whom wished to perform tenotomy of the externus for insufficiency of the interni. When first he received cylindrical glasses, he was made comfortable, but his present distress from muscular asthenopia has lasted 16 months. He was robust and healthy but very excitable and made extreme complaints about his eye troubles. He could not fix upon any moving object nor look for more than a few seconds fixedly at any object. His general nervous condition was so bad, that I put him on bromide of sodium & tr. ergotae. His muscular status was



at 20' with glasses add. =  $30^{\circ}$  }  
 abd. =  $3^{\circ}$  }  $33^{\circ}$   
 v. d. =  $3^{\circ}$  conv.

at 12" with glasses v. d. =  $5^{\circ}$  div.  
 at 7" with glasses v. d. =  $13^{\circ}$  div.

He was ordered

O. D. — 30c  $180^{\circ}$   $\ominus$  prism  $2^{\circ}$  base out }  
 O. S. — 20c  $180^{\circ}$   $\ominus$  prism  $2^{\circ}$  base out } for constant wear.

Within two weeks he was laid up in bed by the passage of a renal calculus, and during this time he did not pay attention to or suffer with his eyes. On getting about again his eye trouble returned and he found his glasses of no benefit. His condition with cylindric glasses was

at 20' add. =  $34^{\circ}$  }  
 abd. =  $2^{\circ}$  }  $36^{\circ}$   
 v. d. =  $1\frac{1}{2}^{\circ}$  conv.

at 12" add. =  $39^{\circ}$  }  
 abd. =  $18^{\circ}$  }  $57^{\circ}$   
 v. d. =  $11^{\circ}$  div.

He had decided spasm A. and I desired to have his eyes put under the influence of atropine, but he went off in a mercantile trip and was absent for 6 weeks. On his return he reported that by help of his prismatic cylinders he could more easily steady his eyes and bear to look out of the window of a railway car. His pain is not now as acute as formerly and sometimes it disappears. He shows in some degree the same nervous or even hysterical symptoms as before

at 20' with cylinders add. =  $34^{\circ}$  }  
 abd. =  $1^{\circ}$  }  $35^{\circ}$   
 v. d. =  $4^{\circ}$  conv.

at 12" with cylinders v. d. =  $15^{\circ}$  div.  
 at 12" v. d. =  $15^{\circ}$  div.

After that time I did not see the patient. He had not reached the status of repose and in his very irritable nervous state it could not easily be attained. In him however there was a marked contradiction between the state of equilibrium for the far and for the near.

I need not cite any more cases of this class in detail. As regards those with myopia I may remark, that there were but 3 which showed any contradiction in the equilibrium for distance and for near. Two of them were essentially cases of spasm of accommodation, and the third was of a kind which Graefe mentions as a limitation of the fusion range at both its extremities. I am not referring to the cases in which a patient voluntarily excludes one eye in reading and lets it go into divergence. These persons usually do not have asthenopia.

Enough has been said regarding the diagnosis and symptoms of the cases in Class II. They seem to me to be worthy of special attention. They have certainly been hitherto imperfectly understood and their treatment has been very unsatisfactory: On this subject I shall have something further to say.

A report may now be given of a small group of cases which might have been divided between the other two classes, but which I have preferred to set by themselves because of their practical value. They are such as for a long time failed to show any signs of insufficiency of the externi, and when this was exhibited they experienced great relief through adductive prisms. They constitute the cases of latency or Class III.

Case XVIII. Miss T., aged 36. Has had a most painful and in-



teresting history. She wounded the median nerve of the right palm many years ago and was treated by many physicians and finally had the operation of exsection of the nerve in the forearm, performed several times under the direction of Dr. Weir Mitchell of Philadelphia, who published the facts in the »American journal of medical sciences«, April 1876, pag. 321.

She was never fully relieved of her neuralgic pain in the brachial plexus, and the disease seemed to continue to extend upwards. She had consulted me about her eyes before the time of the injury to her forearm, which was in 1873 or 1872. In 1882 she applied to a distinguished oculist in New-York for advice, and he gave her + 36s for reading. In March 1884 she came to me and I found her total H. to be  $\frac{1}{16}$  and with these glasses and while still under atropine I found

$$\begin{array}{l} \text{at } 20' + 16s \text{ add.} = 13^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 3^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' + 16s \text{ add.} = 13^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 3^0 \text{ conv.} \end{array}} \right\} 18^0 \qquad \begin{array}{l} \text{at } 12'' + 16s \text{ add.} = 20^0 \\ \text{abd.} = 2^0 \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' + 16s \text{ add.} = 20^0 \\ \text{abd.} = 2^0 \end{array}} \right\} 22^0$$

I ordered + 16s  $\odot$  2<sup>0</sup> p. base out O. U. After two weeks she showed

$$\begin{array}{l} \text{at } 20' + 16s \text{ add.} = 17^0 \\ \text{abd.} = 3^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' + 16s \text{ add.} = 17^0 \\ \text{abd.} = 3^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array}} \right\} 20^0 \qquad \begin{array}{l} \text{at } 12'' + 16s \text{ add.} = 17^0 \\ \text{abd.} = 8^0 \\ \text{v. d.} = 3^0 \text{ div.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' + 16s \text{ add.} = 17^0 \\ \text{abd.} = 8^0 \\ \text{v. d.} = 3^0 \text{ div.} \end{array}} \right\} 25^0$$

She had had spasm of A. which no longer existed.

After two months she reported that there had been a very great improvement in comfort and in capacity for work and her headache had disappeared.

She had

$$\begin{array}{l} \text{at } 12'' + 16s \text{ add.} = 27^0 \\ \text{abd.} = 24^0 \\ \text{v. d.} = \text{—} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' + 16s \text{ add.} = 27^0 \\ \text{abd.} = 24^0 \\ \text{v. d.} = \text{—} \end{array}} \right\} 51^0$$

Case XIX, Miss J., aged 41. Had been under my care ten years ago for chronic palpebral conjunctivitis which was then considered to be asthenopic, but no definite facts were ascertained. She now, May 25, 1883, suffers extreme pain in eyes and head, cannot look steadily at any object and cannot use eyes at all. She has chronic episcleritis at the outer side of the left globe. Is extremely anaemic; her neuralgic pain radiates over the temples, the mastoids, the back of the neck and the vertex. She has spasm A.

$$\begin{array}{l} \text{at } 20' \text{ add.} = 15^0 \\ \text{abd.} = 3^0 \\ \text{v. d.} = \text{—} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 15^0 \\ \text{abd.} = 3^0 \\ \text{v. d.} = \text{—} \end{array}} \right\} 18^0 \qquad \text{at } 14'' \text{ v. d.} = \text{—}$$

I gave atropine and afterwards + 30s to be used in reading.

Five months later it was found, that

$$\begin{array}{l} \text{at } 20' \text{ with } + 30s \text{ add.} = 15^0 \\ \text{abd.} = 2^0 \\ \text{v. d.} = 3^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ with } + 30s \text{ add.} = 15^0 \\ \text{abd.} = 2^0 \\ \text{v. d.} = 3^0 \text{ conv.} \end{array}} \right\} 17^0 \qquad \begin{array}{l} \text{at } 12'' + 30s \text{ v. d.} = 5^0 \text{ div.} \\ 7'' + 30s \text{ v. d.} = 10^0 \text{ div.} \end{array}$$



Guided by the low abduction for 20' I ordered + 48s  $\subset$  2° p. bases out for constant wear. Subsequently for reading + 48s was added to the above formula. She found great benefit from these suggestions suffered very little pain and gained ability to look and to use her eyes. At a later time I gave gymnastic prisms, and she was kept on tonics, chiefly iron and arsenic. Persisting in the use of the glasses as indicated, in 6 months afterwards the situation was

$$\begin{array}{l} \text{at 20' add.} = 23^0 \\ \text{abd.} = - 1^0 \\ \text{v. d.} = 6^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at 20' add.} \\ \text{abd.} \\ \text{v. d.} \end{array}} \right\} 22^0 \qquad \begin{array}{l} \text{at 12'' add.} = 20^0 \\ \text{abd.} = 5^0 \\ \text{v. d.} = 5^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at 12'' add.} \\ \text{abd.} \\ \text{v. d.} \end{array}} \right\} 25^0$$

at 12'' with + 36s finding the same.

Now the position of rest had been gained, and the patient although feeble began to enjoy not only unwanted comfort with her eyes, but improvement in general health.

Case XX. Mr. H., aged 22. Suffered from astigmatism for which in 1878 I gave him a formula as follows

$$\begin{array}{l} \text{O. D.} + 14s - 36c 180^0 \text{ v.} = 20/15. \\ \text{O. S.} + 14s - 36c 180^0 \text{ v.} = 20/15. \end{array}$$

These glasses served his purpose for 5 years and then he began to have trouble with his eyes again. The refractive error was found to be fully corrected by the spherico-cylindrics, but insufficiency of the externi was now evident, for which adductive prisms 2° each were added to his glasses. After he had worn this combination for 3 months the following conditions were noted

$$\begin{array}{l} \text{at 20' with glasses add.} = 34^0 \\ \text{abd.} = 2^0 \\ \text{v. d.} = 6^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at 20' with glasses add.} \\ \text{abd.} \\ \text{v. d.} \end{array}} \right\} 36^0 \qquad \begin{array}{l} \text{at 12'' with glasses} \\ \text{v. d.} = 8^0 \text{ conv.} \end{array}$$

Again 9 months later having continued to wear the same glasses the condition was

$$\begin{array}{l} \text{at 20'' with glasses add.} = 34^0 \\ \text{abd.} = 0^0 \\ \text{v. d.} = 13^0 \text{ conv.} \end{array}$$

In this situation he found enjoyment and the state of repose enabled him to use his eyes comfortably. The weakness of the externi did not show itself until 4 years after my first seeing him and doubtless it was really a reduced state of the nervous supply. He was a delicate man and deeply immersed in business.

*Treatment.* Under this head much has been anticipated in the citation of cases. If what I have to say does not bring forward any new proceedings or appliances, I venture to think, that I may present some of them in a new light and give more satisfactory indications and methods for their use. I may reiterate what has been said as to the value of atropia, when there is clear evidence of spasm of accommodation, and when there is great pain. It acts directly as an anodyne both by setting the ciliary muscle at rest, by assuaging neuralgia, and by the rest which it enforces. Under its use photophobia diminishes, and in as much as it must be carried to its full effects, care is to be taken to avoid if possible its constitutionally toxic influences. Some persons are so suscep-



tibles to it, that very little can be used, and then I prefer homatropine. I ordinarily order a two grain solution of atropia 3 times daily for 3 days and then act according to the results produced. Perhaps this will suffice, perhaps more must be given. For ametropia I give needful glasses and often combine them with prisms.

As to the value of prisms for constant wear I have reached decided convictions. Their effect is not what I anticipated and is really out of proportion to the effect on the position of the visual axes which they are able to produce. I rarely go higher than  $2^{\circ}$  or  $3^{\circ}$  for each eye and the influence of such a low degree upon the visual axes is physically very small. Their effect physiologically is however not small. The patients always complain of them for 24 hours or perhaps for a longer time, that they are made dizzy and that their estimate of the locality and distance of objects is much disturbed. They have trouble in going up and down stairs, and to some extent in walking upon a level. When however the eye muscles have adjusted themselves to the situation, and the glasses have been well chosen, a feeling of rest is acquired and then the total muscularity improves. Perhaps before prisms can be advantageously used, atropine must be employed, but this necessity will not always exist. I have not found that with constant wear of adductive prisms the abduction has in all cases improved. On the contrary there is usually a marked reduction in the capacity for abduction. In mild cases such is not the effect and in time the prisms may be laid aside: but in severe cases the prisms will have to be worn permanently. They introduce the muscles into a condition of repose, and thereafter ensue improved vigor and comfort, but the modification of the visual axes which they bring about seems in many cases to be the fixed ultimate condition which the patient must maintain and to the glasses he will be permanently indebted to enable him to maintain it. It may be that decided improvement in condition of health when this is enfeebled will enable the patient to lay aside the glasses. On the other hand very severe cases of insufficiency of the externi will not be relieved by prisms or medical treatment and must be dealt with by operation i. e. by tenotomy of the interni. Some cases, which for a period have enjoyed great relief by adductive prisms, after a time cease to derive benefit from them and must have tenotomy. Out of the 82 cases now reported, 4 had tenotomy of the interni, two required it at the beginning, 2 used prisms for many months with benefit, before the operation was done. In no case do I resort to tenotomy unless a very emphatic necessity for it can be demonstrated.

At the risk of tediousness I give an analysis of the treatment of the cases of insufficiency. By so doing the reader will be better able to form a judgement of the value of the methods employed and may see, what were the real causes of success or of failure.

I begin with Class I. There were 63 cases, divided in regard to refraction as follows:

E. = 18, H. = 22, M. = 10, Astigm. = 13.

Among them some cases were not heard of after they were prescribed for; some refused treatment or it was not continued long enough to produce proper results, and these cases are not included in the examination. There were of such cases, in E. : 5, in H. : 2, in M. : 6, in Astigm. : 5.



Of the cases of emmetropia the 13 whose subsequent history is known, may be summed up, as follows.

*Class I.* One patient had had asthenopic symptoms for years and met with an accident by which one upper eyelid was badly lacerated. I treated him for this and within a short time after recovery he asked advice about his muscular asthenopia, but did not persevere in attending to it. I gave him prisms and would have used atropine, if I had had the opportunity. For another case I tried adductive prisms but they were not so serviceable as weak convex glasses, which were used with more or less persistency for 10 years and only in near work. Chronic blepharitis was the special form of asthenopia and the refusal to use adductive prisms was a surprise because there was such considerable deficiency in the externi. In brief the case is, as follows.

Case XXI. Dr. L., aged 36, seen in June 1874. E.  $20/20$ , no atropine.

$$\begin{array}{l} \text{At } 20' \text{ add.} = 26^0 \\ \text{abd.} = 3\frac{1}{2}^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{At } 20' \text{ add.} = 26^0 \\ \text{abd.} = 3\frac{1}{2}^0 \\ \text{v. d.} = 4^0 \text{ conv.} \end{array}} \right\} 29\frac{1}{2}^0 \qquad \text{at } 14'' \text{ v. d.} = 4^0 \text{ conv.}$$

I gave adductive prisms  $2^0$  for near work. They for a time seemed to give relief, but afterwards  $+ 48s$ , were preferred. In May 1884 the condition was

$$\begin{array}{l} \text{at } 20' \text{ add.} = 17^0 \\ \text{abd.} = 4^0 \\ \text{v. d.} = 2^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 17^0 \\ \text{abd.} = 4^0 \\ \text{v. d.} = 2^0 \text{ conv.} \end{array}} \right\} 42^0 \qquad \begin{array}{l} \text{at } 12'' \text{ add.} = 37^0 \\ \text{abd.} = 12^0 \\ \text{v. d.} = 15^0 \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{at } 12'' \text{ add.} = 37^0 \\ \text{abd.} = 12^0 \\ \text{v. d.} = 15^0 \text{ conv.} \end{array}} \right\} 49^0$$

$$\begin{array}{l} \text{at } 12'' \left\{ \begin{array}{l} \text{add.} = 25^0 \\ \text{abd.} = 12^0 \end{array} \right\} 37^0 \\ + 24s \left\{ \begin{array}{l} \text{v. d.} = 10^0 \text{ conv.} \end{array} \right\} \end{array}$$

He reads with  $+ 24s$  and its effect is simply to reduce the adduction without increasing the abduction, but the displacement with vertical diplopia is by it decidedly diminished. The gentleman has robust health and does severe work with his eyes and never has pain in them. It has seemed to me that his preference for convex glasses rather than for prisms might be due to his vigorous health and good accommodation and absence of all symptoms of nervous irritation.

Another case also preferred convex glasses for near work to adductive prisms, but the record is not very complete.

Another case was not adequately benefitted either by atropine or by prisms, or by tenotomy which I performed. The case was peculiar and I omit to give it in detail. Of the remaining cases two (5,8) had very large admixture of spasm A. and were cured chiefly by atropine, although adductive prisms were also employed.

The remnant, viz 7 cases, which complete the 13 Emmetropics were all provided with adductive prisms either for near work or for both near and distance and all derived positive benefit from them, and my knowledge of their subsequent history qualifies me to speak with certainty about them.

The degree of benefit was various according to the conditions of health, age, and occupation, but the usefulness of the prisms was unmistakable.



Of 10 cases of myopia which belong in this class, there are 6 of whose subsequent history I know nothing. Of these 3 were very slightly myopic, and for them I ordered prismatic glasses. Of the remaining 3, one had homonymous diplopia, and tenotomy was advised, and the other two were highly myopic, viz, each 11 D., and were provided with concave glasses, which only partially corrected their myopia.

Of the four, whose history is known, one had M. 7 D. and was contented with  $-4.5$  D. for distance and  $-3.25$  D. for reading. Another, who had  $-4$  D., received this with adductive prism  $2^{\circ}$  for distance and  $-2$  D. for reading.

Case XXII. Another had  $-1$  D. and had been using  $+0.75$  D. to relieve headache in reading. After using atropine, adductive prisms  $2\frac{1}{2}^{\circ}$  each were given, and they entirely relieved his symptoms. His muscular findings were, as follows

$$\begin{array}{r} \text{at } 20' - 42\text{s} \text{ add.} = 27^{\circ} \\ \text{abd.} = 9^{\circ} \\ \text{v. d.} = 5^{\circ} \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{add.} \\ \text{abd.} \\ \text{v. d.} \end{array}} \right\} 36^{\circ}$$

Sixteen months afterwards, having used  $-48\text{s} \subset 2\frac{1}{2}^{\circ}$  prisms, base out, he showed

$$\begin{array}{r} \text{at } 20' - 48\text{s} \text{ add.} = 20^{\circ} \\ \text{abd.} = 2^{\circ} \\ \text{v. d.} = 15^{\circ} \text{ conv.} \end{array} \left. \vphantom{\begin{array}{l} \text{add.} \\ \text{abd.} \\ \text{v. d.} \end{array}} \right\} 22^{\circ}$$

Here was a notable decline in the total muscularity, a great increase of the convergence for distance, but also the enjoyment of comfort, and this was known to continue 6 months after the last examination. The explanation was that his visual axes had found their place of repose.

The last of this group of cases was one of M.  $-8$  D. She had extreme pain and asthenopic symptoms. Had once before had tenotomy of the rectus internus and I performed a similar operation on the internus of the other eye. The case need not be reported in detail.

Of these four myopic cases two were relieved by giving them partially correcting glasses, one by prisms with full correction, and one by tenotomy.

Of hypermetropic cases in the present group there were 22, in two of whom the subsequent history is unknown. On the remaining 20 the effect of treatment was, as follows.







Refraction &c.	Treatment.	Muscles.	Results.
<p>1. H. + <math>\frac{1}{24}</math>. Female 12, severe headache for 2 years, spasm A.</p>	<p>Atropine, ordered + 48 s  <math>\ominus</math> 2° add. prism: afterwards  + 36 s <math>\ominus</math> 5° add. prism, constant use.</p>	<p>20' add. = 20° } 23°  abd. = 3° }  v. d. = 3° conv.  became in 2 months  20' add. = 28° } 30°  abd. = 2° }  v. d. = 13° conv.</p>	<p>Complete relief from pain in head and eyes, ability to read moderately. The ultimate effect of the higher adductive prisms not known.</p>
<p>2. H. + <math>\frac{1}{36}</math>. Female 16, fatigue of eyes for 18 months. Wants to shut them. Not much pain.</p>	<p>Atropine. + 48 s <math>\ominus</math> 3° add. prism, constant use.</p>	<p>20' add. = 40° } 44°  abd. = 4° }  v. d. = 5° conv.</p>	<p>The subjective symptoms relieved. The young lady refused to wear glasses and withdrew.</p>
<p>3. H. + <math>\frac{1}{60}</math>. Male 14. Chronic blepharitis for years. Eyes itch and have attacks of conjunctivitis. Fatigue.</p>	<p>Treatment of lids and conjunctiva.  2° add. prism for reading.</p>	<p>20' add. = 23° } 29°  abd. = 6° }  v. d. = 3° conv.</p>	<p>Irritation of lids cured. Felt much comfort with glasses in reading. Effect known for 3 months, and glasses used in all continuous work.</p>
<p>4. H. + <math>\frac{1}{24}</math>. Female 44. Trouble 4 years, pain in eyes. Spasm A.</p>	<p>Atropine 10 days, then + 36 s <math>\ominus</math> 2° add. prism for distance and + 10 s <math>\ominus</math> 2° add. prism for reading.</p>	<p>20' and + 24 s  add. = 15° } 21°  abd. = 6° }  v. d. = 4° conv.  became in 10 weeks  20' + 36 s add. = 33° } 38°  abd. = 5° }  v. d. = 3° conv.</p>	<p>Subjective symptoms removed. Able to use eyes longer, but would after a time become tired.</p>
<p>5. H. + <math>\frac{1}{24}</math>. Male 12. Pain in eyes and especially at root of nose, cannot fix steadily. Of small stature and delicate health.</p>	<p>Atropine 10 times. 2° add. prism constant wear; after a month + 36 s <math>\ominus</math> 4° add. prism; after 5 weeks directed gymnastic prisms, after 2 months more did tenotomy.</p>	<p>20' + 24 s add. = 18° } 23°  abd. = 5° }  v. d. = <del>2°</del>  12' + 24 s v. d. = 14° conv.  became in 5 months,  20' add. = 40° } 42°  abd. = 2° }  v. d. = 13° conv.  after tenotomy one month  20' + 36 s add. = 25° } 33°  abd. = 8° }</p>	<p>Very marked relief in subjective symptoms, which almost disappeared; gained some power to use eyes, before operation was done.  Result of operation was good. Effect noted only for one month.</p>



able to use eyes.

Moderate spasm A.

7. H. t. + 1/48. Male 17.  
Severe palpebral conjunctivitis.  
Has grown very tall, is not  
strong. Has nasal catarrh.

8. H. t. + 1/36. Male 12.  
Pain in eyes and head for 3  
years. Delicate health.

9. H. t. 1/36. Female 32;  
Great pain in eyes for several  
years. Much uterine trouble  
and feeble health.

10. H. t. 1/24. Female 41.  
Always delicate health. Weak

Atropine. Treated con-  
junctivitis and nasal catarrh,  
gave gymnastic prisms and  
after month 2° add. prism,  
constant wear.

Atropia. Gave 48s  $\ominus$  2°  
add. prism for constant wear.  
In 10 days gave + 48s  $\ominus$  4°  
add. prism. After 6 weeks +  
48s  $\ominus$  6° add. prism. In 2  
months more + 48s  $\ominus$  4°  
add. pr. 2 months afterwards  
+ 48s  $\ominus$  2° add. pr. and  
gymnastic prism. 3 months  
after did tenotomy.

Gave + 48s  $\ominus$  2° add.  
prism for constant wear. After  
5 months gave + 36s  $\ominus$  3°  
add. prism for constant use.

Gave + 24s for reading.  
After 2 months + 36s for  
distance. After 6 weeks gave

became in 2 months

20' + 30s add. = 23° } 28°  
abd. = 5° }  
v. d. =  $\ominus$

20' + 48s add. = 16° } 23°  
abd. = 7° }  
v. d. =  $\ominus$   
14'' v. d. = 5° conv.

became in one month  
20' add. = 23° } 30°  
abd. = 7° }  
v. d. = 1° conv.

20' + 36s add. = 15° } 22°  
abd. = 7° }  
v. d. = 3° conv.

became in 2 months  
20' + 36s add. = 26° } 30°  
abd. = 4° }  
v. d. = 11° conv.

Before operation

20' add. = 30° } 36°  
abd. = 6° }

10 weeks after operation

20' add. = 35° } 45°  
abd. = 10° }  
v. d. = 3° conv.

20' add. = 23° } 28°  
abd. = 5° }  
v. d. = 5° conv.

after 5 months

20' + 48s add. = 29° } 33°  
abd. = 4° }  
v. d. = 7° conv.

20' + 24s add. = 13° } 18°  
abd. = 5° }  
v. d. = 1° conv.

Treatment did not accomplish decided  
benefit. Patient withdrew; result un-  
known; unsatisfactory.

Improvement in headache and pain  
in eyes began with treatment, and be-  
came better and better. Ability to use  
eyes increased, but not sufficient with  
glasses. Effect of operation was very  
satisfactory both to subjective symptoms  
and by tests of muscles.

Relief was moderate; she used the  
glasses almost entirely in reading and  
did not wear them continuously as directed.  
Health very poor.

Not much benefit from treatment.  
Health continued poor and eyes were  
about as before.



Refraction &c.	Treatment.	Muscles.	Result.
<p>lungs. Much uterine trouble. Pain in eyes several years.</p> <p>11. H. <math>\frac{1}{90}</math>. Male 15. Always had trouble with eyes. Has used + 48 in reading. Is tall and slender. Spasm A.</p>	<p>+ 48 s <math>\ominus</math> 2° add. prism for all purposes.</p> <p>Atropine 1 week. Gave + 30s <math>\ominus</math> 2° add. prism, after 2 weeks gave + 30s <math>\ominus</math> 7° add. prism, after 8 months gave 9° add. pr. for distance same as before for reading; 4 months later did tenotomy.</p>	<p>12" + 24s v. d. = 5° conv. After 4 months 20' add. = 15° } 20° abd. = 5° } v. d. = <math>\frac{1}{2}</math></p> <p>20' + 30s v. d. = 9° conv. After 6 months use of + 30s <math>\ominus</math> 7° add. prism 20' + 30s add. = 30° } 33° abd. = 3° } v. d. = 16° conv.</p> <p>23 months after beginning treatment</p> <p>20' add. = 28° } 30<math>\frac{1}{2}</math>° abd. = 2<math>\frac{1}{2}</math>° } v. d. = 10—15° conv.</p> <p>5 months after tenotomy</p> <p>20' add. = 45° } 55° abd. = 10° } v. d. = 3° conv.</p> <p>20' abd. = 1° v. d. = 10°</p>	<p>Subjective symptoms controlled by prism to very great degree and was able to use eyes vigorously. This lasted for 18 months by glasses. Then spasm A recurred, and pain renewed. Was obliged to have tenotomy. Effect very satisfactory.</p>
<p>12. H. <math>\frac{1}{30}</math>. Male 37. Trouble with eyes 8 years. Used + glasses. Health good.</p>	<p>Gave 4° add. prism, which could not be worn. Tenotomy of left rectus internus. After 13 months tenotomy of right rectus internus.</p>	<p>After 1 month 20' add. = 52° } 52° abd. = 0° } v. d. = 20° conv.</p> <p>5 weeks after tenotomy</p> <p>20' add. = 22° } 31° abd. = 9° } v. d. = 6° conv.</p> <p>1 year after tenotomy</p> <p>20' add. = 30° } 35<math>\frac{1}{2}</math>° abd. = 5<math>\frac{1}{2}</math>° }</p> <p>Did tenotomy on other eye 1 year later</p> <p>20' add. = 25° } 31° abd. = 6° }</p>	<p>Prisms were not satisfactory. First tenotomy gave extreme relief. But 1 year later patient wanted to be further assisted, and by second tenotomy there was moderate benefit, which subsequently increased, and now, 1 year after second operation, he is entirely relieved.</p>





<p>and used again.</p>	<p>Gave + 30s <math>\ominus</math> 3° add. prism. To practice reading by regulated increase. Afterwards wear glasses constantly, 2 months later to use them only in reading.</p>	<p>20' add. = 40° } 43° abd. = 3° } v. d. = 5° conv. 14'' + 36s v. d. = 15° conv.</p>	<p>for a few months. After that again well.</p>
<p>and used again.</p>	<p>Atropine. Gave 3 1/2° add. prisms, advised tenotomy.</p>	<p>20' add. = 50° Has homonymous diplopia with a red glass. 12'' v. d. = 18° conv.</p>	<p>Found much relief from glasses. This known to be permanent.</p>
<p>and used again.</p>	<p>Gave 2° add. prisms. Then atropine. To use above prisms for distance and + 36s <math>\ominus</math> 3° add. prism for reading.</p>	<p>20' add. = 15° } 20° abd. = 5° } v. d. = 5° 12'' v. d. = 5° conv. After month became 20' add. = 23° } 28° abd. = 5° } v. d. = 2° conv.</p>	<p>Could hardly hold eyes steady for examination, not much benefit from prisms. Declined operation. Withdrew from observation.</p>
<p>and used again.</p>	<p>Atropine 2 weeks.</p>	<p>20' add. = 23° } 28° abd. = 5° } v. d. = 15° conv. After atropine 12'' v. d. = 10° conv.</p>	<p>Was fully relieved of all symptoms. Known to continue so for 3 months.</p>
<p>and used again.</p>	<p>Gave + 36s reading and afterwards constantly. Then gave + 24s <math>\ominus</math> 3° add. pr. Gave strychnine, removed 1 prism. Then removed other pr. leaving + 24s. Finally + 18s <math>\ominus</math> 3° add. pr.</p>	<p>14'' + 36s v. d. = 11° conv. After treatment for 1 year had 20' add. = 22° } 25° abd. = 3° } 20' + 16s add. = 12° } 18° abd. = 6° }</p>	<p>The changes of prisms and glasses were made, as symptoms arose. No atropine used and under prism latent H. became manifest. Was finally made comfortable and so remained.</p>
<p>and used again.</p>	<p>Gave + 36s <math>\ominus</math> 2° add. prism.</p>	<p>20' add. = 25° } 30° abd. = 5° } 14'' v. d. = 8° conv.</p>	<p>Was not relieved by prisms and withdrew, not seen after 3 weeks. History unknown.</p>
<p>and used again.</p>	<p>Gave + 48s 3° add. prism.</p>	<p>20' add. = 27° } 30° abd. = 3° } 15'' v. d. = 10° conv.</p>	<p>Was partially relieved. Prisms were helpful.</p>

14. H. 1/36. Female 37. Under treatment a year for eyes.

15. Ht 1/48. Female 21. Palpebral conjunctivitis severely for several years. Lately worse asthenopic symptoms.

16. Ht. 1/48. Female 14. Chronic conjunctivitis, severe head-ache, cannot use eyes.

17. H. 1/24. Female 10. Tremor of globes at outer angles. Pain in eyes. Spasm A.

18. H. 1/36. Male 26. 1871.

19. H. 1/50. Male 37. Has homonymous diplopia at 20'. 1875.

20. Ht. 1/24. Male 22. 1875.



Of the above 20 cases nos. 19 and 7 did not give treatment a fair trial; nos. 10 and 9 were females with serious uterine and other disease, and it was not expected that much relief could be afforded; no. 15 declined to accept an operation; no. 2 was unwilling to wear any glasses and demanded an operation which I was unwilling to perform at that time; no. 17 had chiefly spasm A.

Of the remaining 13 one, viz no. 6, was relieved completely by atropine and spherical glasses, and twelve used adductive prisms with or without convex glasses with greater or less benefit. In two cases very high prisms were employed, viz in nos. 11 and 8, amounting respectively to  $14^{\circ}$  and  $8^{\circ}$ . In both these cases and in one other (no. 12) tenotomy was performed. On the whole the effect of prisms was extremely satisfactory. While they did not in all cases greatly increase the muscular power, they induced the status of repose and thus brought relief.

In a more succinct manner I may refer to the cases of astigmatism under the present head. Of these there are 13, and regarding their subsequent history, in 5 nothing is known. I shall therefore deal only with the remaining 8. One case is still under treatment, and promises to yield a good result. In all of the cases atropine was used, the necessary refractive correction given, and these glasses were in all instances save one combined with adductive prisms. Nothing especially noteworthy or different in essential character is to be found among these cases, as compared with those, having hypermetropia, of which I have given a table. Moreover the 7 cases, which have been seen to the end of treatment, have been also known to be permanently benefitted.

I take next in order 14 cases, in which the muscular conditions at the far and near points of the fusion range were dissimilar, viz. Class II.



Refraction &c.	Treatment.	Muscles.	Result.
1. M. Male 18, see above case XV. Great spasm A.	Atropine on two different occasions; corrective glasses for distance; none for near. No prisms.	20' add. = 30 <sup>0</sup> 33 <sup>0</sup> abd. = 3 <sup>0</sup> became 20' add. = 21 <sup>0</sup> 23 <sup>1/2</sup> <sup>0</sup> abd. = 2 <sup>1/2</sup> <sup>0</sup>	Was fully and permanently relieved. Treated twice in 2 years. Been well for 5 months. Myopia slightly increased.
2. Male 23, see above case XIV. Great spasm A.	Atropine. Corrective glasses for distance, then corrective glasses combined with add. prisms for near. Atropine again.	20' with glasses add. = 18 <sup>0</sup> 23 <sup>0</sup> abd. = 5 <sup>0</sup> became add. = 20 <sup>0</sup> 31 <sup>0</sup> abd. = 11 <sup>0</sup>	Treated during 20 months. Adequate relief. Finally used partial correction for near, full correction for distance and no prisms.
3. M. Male 51; Never used glasses in reading and not much for distance. Case XVI.	Never developed his A. To use very weak correction for near, and full correcting glass with add. prism for distance.	20' with glass add. = 18 <sup>0</sup> 21 <sup>0</sup> abd. = 3 <sup>0</sup> v. d. = 4 <sup>0</sup> conv.	Seen during 21 months. The use of concave prisms not been continued long enough to know the true result.
4. E. Male 12. Reported above in full as case XIII.	Abductive prisms for near. Gymnastic prisms. Finally adductive prisms, also treated nasal catarrh and conjunctivitis.	20' add. = 15 <sup>0</sup> 20 <sup>0</sup> abd. = 5 <sup>0</sup> became 20' add. = 40 <sup>0</sup> 43 <sup>1/2</sup> <sup>0</sup> abd. = 3 <sup>1/2</sup> <sup>0</sup> 12'' add. = 60 <sup>0</sup> 75 <sup>0</sup> abd. = 15 <sup>0</sup>	Subjective symptoms entirely relieved. Ability to use eyes much increased. Treated during 18 months. Improvement held good 5 months.
5. H. Male 34. Had used convex glasses. Had used convex abductive prisms for near without avail. Case VIII.	Adductive prisms for far and near. Convex adductive prisms for near.	20' with glasses add. = 34 <sup>0</sup> 36 <sup>0</sup> abd. = 2 <sup>0</sup> became add. = 45 <sup>0</sup> 47 <sup>0</sup> abd. = 2 <sup>0</sup> at 12'' with glasses add. = 50 <sup>0</sup> 73 <sup>0</sup> abd. = 23 <sup>0</sup>	Pain and subjective symptoms immediately relieved. Great and permanent increase in ability to use eyes. Treated during 3 months. Improvement known to remain until now, i. e. 3 months longer.



Refraction &c.	Treatment.	Muscles.	Result.
6. H. Female 56. Has chronic blepharitis marginalis.	Prescribed for lids and conjunctiva. Did not treat muscles.	Has insufficiency of externi and of interni.	
7. H. Male 64. See above case XII.	Convex abductive prisms for near. Gymnastic prisms. At late period used adductive prisms for distance and convex adductive for near.	20' add. = 13° abd. = 5° 12'' + 12s v. d. = 12° div. became 20' add. = 35° abd. = 4° 12'' + 12s v. d. = 9° div.	Subjective symptoms not notably improved, until add. prisms were given. Moderate improvement by abductive and gymnastic prisms, but most decided increase in ability of eyes by adductive prisms. Treated 1 year. Improvement by add. prisms during 1 month.
8. H. Female 17. Severe pain and spasm A. See case XVIII.	Atropine and convex glasses. Afterwards convex add. prisms for distance and near.	not recorded.	Subjective symptoms removed. Satisfactory ability to use eyes, continue glasses for near, not for far. Treated 4 months. Condition maintained till now, is 6 months.
9. Astigm. Female 44. for 10 years used cylindrical glasses, and then had trouble again. Case XIV.	Added spherical curve to cylinders to correct presbyopia. Gymnastic prisms.	20' with glasses add. = 20° abd. = 5° 12'' with glasses add. = 27° abd. = 17° became 20' w. gl. add. = 40° abd. = 5° 12'' w. gl. add. = 45° abd. = 14° 45° 59°	Pain and weariness removed. Improvement in ability to use eyes; not complete restoration. Treated 10 <sup>1</sup> / <sub>4</sub> years.
10. Astigm. Female 35. Used cylinders 15 years. See case XXI.	Changed the cylinders. Atropine. Paracentesis corneae. Abd. prisms with cylinders. Gymnastic prisms. Advancement of rectus internus. Add. prisms with cylinders.	20' with glasses add. = 8° abd. = 5° became 20' w. gl. add. = 16° abd. = 5° 21°	Pain and weariness mitigated, not entirely removed. Increase in ability to use eyes, but not complete restoration. Case not completed.



<p>11. Astigm. Male 30. Had used cylinders for 2 years. Pain and severe spasm. A. Case XVII.</p>	<p>Gave cylinders with add. prisms. Then atropine; to continue glasses.</p>	<p>20' with glasses add. = 30<sup>0</sup> 33<sup>0</sup> abd. = 3<sup>0</sup> became 20' with glasses add. = 34<sup>0</sup> 35<sup>0</sup> abd. = 1<sup>0</sup></p>	<p>Some relief to subjective symptoms and some improvement in ability to use eyes. Did not use atropine soon enough. Relief incomplete.</p>
<p>12. Astigm. Male 22. Seen only for examination. Case XVI.</p>	<p>Ordered gymnastic prisms.</p>	<p>20' add. = 26<sup>0</sup> 29<sup>0</sup> abd. = 3<sup>0</sup></p>	<p>No relief obtained. Treatment was incorrect.</p>
<p>13. Astigm. Male 27. Severe symptoms of head as well as of eyes. Case XXV.</p>	<p>Gave add. prisms, then atropine. Finally convex cylinders.</p>	<p>20' add. = 14<sup>0</sup> 22<sup>0</sup> abd. = 8<sup>0</sup> became 20' add. = 30<sup>0</sup> 35<sup>0</sup> abd. = 5<sup>0</sup></p>	<p>Was partially relieved; ought to have had adductive prisms at the last. Incomplete relief.</p>
<p>14. Astigm Male 24. Had used cylinders for 18 months. Case XV.</p>	<p>Gave cylinders and add. prisms for both far and near. Gymnaastic prisms.</p>	<p>20' add. = 23<sup>0</sup> 28<sup>0</sup> abd. = 5<sup>0</sup> became 20' add. = 55<sup>0</sup> 59<sup>0</sup> abd. = 4<sup>0</sup></p>	<p>Relief was satisfactory both as to the pain and as to ability to use eyes. Seen during 2 years. Relief maintained for 2 months.</p>



Of the above cases, in no. 6 no treatment of the muscles was attempted, in one, no. 12, no relief was obtained because the treatment was unsuitable; in four, nr. 9, 10, 11 & 13, partial relief was secured, and of these the imperfect result was due, in two, nos. 11 and 13, to error in not using different proceedings, in the others, nos. 9 & 10, the general conditions were unfavorable and the local measures were such as were best calculated to do service.

Of the remaining cases, nos. 1 & 2 were properly cases of spasm of A., while in no. 3 the ultimate effect was not yet known. There remain 5 cases in this category, in which adductive prisms had a most happy and decisive influence, viz nos. 4, 5, 6, 7, 8 & 9. I will not undertake to apportion the benefit, which some of them may have obtained by treatment employed before such prisms were used. But my convictions are very strong that for those who did not at an early period employ adductive prisms the success would have been more speedy if they had been then employed. At the same time the error of the externi was no exhibited in all of them until a late period and for such cases our means of diagnosis do not suffice until the suggestive symptoms appear.

One of the above cases presented itself to me as a lesson, viz.

Case XXIII. Mr. C., aged 27, a highly nervous man and a hard student, himself neurotic and coming from neurotic parents. Had severe headache and various nervous symptoms and was commended to me in Sept. 1882, by Dr. Weir Mitchell of Philadelphia. He had had much trouble with his eyes, but he complained chiefly of his head. His refraction without atropine was O. U. E.  $20/20$ , no spasm of A.

$$\begin{array}{l} \text{at } 20' \text{ add.} = 10^0 \\ \text{abd.} = 8^0 \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 10^0 \\ \text{abd.} = 8^0 \end{array}} \right\} 18^0 \\ \text{v. d.} = 4^0 \text{ div.}$$

I gave him abductive prisms, i. e.  $2^0$  for constant wear. After using them for 11 days, he reported his condition as no better, and one of his chief troubles was palpebral conjunctivitis:

$$\begin{array}{l} \text{at } 20' \text{ add.} = 14^0 \\ \text{abd.} = 8^0 \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 14^0 \\ \text{abd.} = 8^0 \end{array}} \right\} 22^0 \qquad \text{at } 14'' \text{ v. d.} = 8^0 \text{ div.}$$

The abductive prisms were increased adding  $2^0$ . To the left eye, but this only made him more uncomfortable and in a week he reverted to the original prisms. For 3 weeks longer he wore them and the condition became

$$\begin{array}{l} \text{at } 20' \text{ add.} = 12^0 \\ \text{abd.} = 5^0 \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 12^0 \\ \text{abd.} = 5^0 \end{array}} \right\} 17^0$$

which in 5 days became

$$\begin{array}{l} \text{at } 20' \text{ add.} = 21^0 \\ \text{abd.} = 6\frac{1}{2}^0 \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 21^0 \\ \text{abd.} = 6\frac{1}{2}^0 \end{array}} \right\} 27\frac{1}{2}^0 \qquad \text{at } 14'' \text{ v. d.} = 2^0 \text{ conv.}$$

Then atropine was employed, which revealed a trifling astigmatism, which however was thought to be of importance to him, after the atropine effect had passed, he was found to have

$$\begin{array}{l} \text{at } 20' \text{ add.} = 30^0 \\ \text{abd.} = 5^0 \end{array} \left. \vphantom{\begin{array}{l} \text{at } 20' \text{ add.} = 30^0 \\ \text{abd.} = 5^0 \end{array}} \right\} 35^0 \qquad \text{at } 14'' \text{ v. d.} = 2^0 \text{ conv.}$$

He was given for constant use:  $\left\{ \begin{array}{l} \text{O. D.} + 96c \ 90^0 \\ \text{O. S.} + 60c \ 90^0 \end{array} \right.$



In a month he gained a little benefit. He had much dyspepsia and other disturbances and could with difficulty read for  $\frac{1}{2}$  an hour at a time. I regret that as the result of the last finding of the muscular power I did not direct the use of adductive prisms instead of cylinders. I can but think that then this case would have had some of the same benefit, which was obtained by case XI (Jones) and case XIX (Craig), both of whom went through somewhat similar experiences. It would no doubt have been better to have used atropine early. It is certainly surprising, that a state of marked debility of the interni such as Mr. C. exhibited should have passed over into a condition of incapacity of the externi, which though not great was as I now believe the real error. In the beginning the total muscularity was very low, viz 22, and the ratio of abduction was high: there was also divergence by the equilibrium test both for the far and for the near. All the findings thus concurred in the diagnosis of insufficiency of the interni with weak muscular capacity in general. It is evident, that the abductive prisms had a good influence, because the muscular power rose to  $35^0$ , and the relation between adduction and abduction was being brought to view, as they existed in him. Had I then appreciated the situation, as I do now, I would have given adductive prisms for distance, by means of which his status of repose might have been developed, and the asthenopia perhaps wholly relieved.

I do not assert that it may not sometimes be well to give abductive prisms for near work, where divergence is exhibited, and adductive prisms for distance, when convergence is shown, but even in this class of cases I have been astonished to find, that adductive prisms constantly worn, have met all the indications and given adequate relief. I have read with much interest Dr. Kugel's report of his own experience in Graefe's Archives, but I beg to offset this with the case of Mr. Root, Case VIII, who had tried abductive prisms for near work with entire failure, and who first gained relief by wearing adductive prisms for all purposes. Other less striking cases are found in the table.

These cases although few in number seem to me sufficient to show, that relief of strain afforded by weak prisms amounting only to  $4^0$  as a total will in most instances bring about a remarkable improvement, in the capacity of the muscles for work and at the same time a corresponding improvement in the distressing asthenopic symptoms. Prisms employed in this way act only as a rest to the muscles, they are totally different in mode of action from gymnastic or exercising prisms<sup>1)</sup>.

These latter I employ in many cases and have done so for many years, and Graefe was also in the habit of using them. I have learned, that they are not suitable until the condition of strain or overfatigue has been relieved, by atropine and rest and by adductive or abductive prisms worn for a sufficient period of time.

Next I summarise 5 cases, which for a long time exhibited other conspicuous symptoms, which suppressed the true situation of the external recti, and they may be given as Class III.

<sup>1)</sup> The Effect adductive prisms of  $4^0$  is in reality not so small as may be supposed. With a metric angle of  $1^0 50'$  they produce a deviation of 5G (metric angle) which in linear measure feets the convergence at about 6 feet (2 metres distance).



CLASS III.

Refraction &c.	Treatment.	Muscles.	Result.
<p>1. H. Female, 36. Formerly had + glasses, suffered greatly from traumatic neuritis of brachial plexus. See Case XVIII.</p>	<p>Atropine; convex glasses combined with add. prisms for near and far.</p>	<p>20' with glasses add. = 13° abd. = 5° } 18° became 20' w. gl. add. = 17° abd. = 3° } 20°</p>	<p>Pain and weariness disappeared. Ability to use eyes decidedly better. Improvement noted during 3 1/2 months.</p>
<p>2. H. Female 41. Had palpebral conjunctivitis and episcleritis. See case XIX.</p>	<p>Atropine and + convex glasses for reading, then + glasses with add. prisms for far and near. Gymnastic prisms.</p>	<p>20' with glasses add. = 15° abd. = 2° } 17° became 20' w. gl. add. = 23° abd. = 1° } 22°</p>	<p>Entire relief from extreme pain and inability to fix eyes. Gaining power to use eyes on work. Relief progressing. Improvement noted during 6 months.</p>
<p>3. H. Female 36. Besides asthenopia has episcleritis in one eye.</p>	<p>Atropine, convex 30s for constant use, gymnastic prisms, add. prisms for distance, convex glasses for near.</p>	<p>20' add. = 15° abd. = 2° } 17°</p>	<p>Found prisms very helpful and also indispensable, without them had homonymous diplopia. Ability to use eyes improved.</p>
<p>4. H. 1/48. Female 38. Symptoms those of spasm A. See case VII.</p>	<p>Used atropine vigorously. Add. prisms for far and near.</p>	<p>20' add. = 20° abd. = 5° } 25° became 20' add. = 32° abd. = 5° } 37°</p>	<p>Subjective symptoms wholly removed. Able to use eyes. Cure noted during 4 months.</p>
<p>5. Astig. Male, 22. Had cylinders for 4 years, then came trouble again. See case XX.</p>	<p>Combined adductive prisms with cylindrical glasses.</p>	<p>Ultimate condition: 20' and glasses add. = 34° abd. = 0° } 34°</p>	<p>The add. prisms restored him to comfort and to the ability to use his eyes. General health not good. Relief noted during one year.</p>



Of these cases one, viz no. 4, might perhaps be eliminated, because it proved to be a case of spasm of A., and which was very soon discovered, after atropine had been sufficiently employed, but I put it in this category, because the need of adductive prisms was to me a surprise. Of the remaining four cases it may be said, that the adductive prisms completed the cure, which had hitherto been delayed, and became to the patients a source of great satisfaction.

It would be almost a culpable omission, if I should fail to state that, while I have treated the above cases of asthenopia with such and such local appliances, I have never lost sight of those conditions of general health, which may have had a bearing upon the eye troubles, and have often called to my aid the skilful of other practitioners for the treatment of remote conditions. In all that relates to general hygiene I never neglect to give urgent advice and particular instructions. Conditions of ill health so frequently occasion or complicate asthenopia, that by many practitioners attention to the general health is thought to be all sufficient to remove the eye troubles. I have endeavoured to show, that local measures are valuable in a high degree. I have sought to give more precision to the indications for the appliances for local treatment. Knowing well how little faith has come to be placed by able and discriminating ophthalmologists in the value and real efficacy of prisms in asthenopia, I have sought to first make clear the true diagnostic signs of muscular asthenopia, and I have not spared labor in attempting to find among my successful cases, what were the true causes of success, nor have I shrunk from facing the true causes of failure, when the responsibility for it has come home to myself. I cannot absolutely declare, whether prisms or other glasses or both combined will in a given case procure relief, but I am certain, that a value is to be found in the correct employment of prisms, which makes the study of their effects and the indications for their use a most hopeful undertaking.

I put together in a general summary the results of treatment of the cases, which have formed the subject matter of this paper as follows, and I also keep apart the three classes, which I have arbitrarily made.

	Class I.	Class II.	Class III.	Totals.
History unknown . . . . .	18	»	»	18
Treatment not adopted } or not continued } . . . . .	4	1	»	5
Remaining under treatment . . . . .	2	1	»	3
Failure . . . . .	1	1	»	2
Partial success . . . . .	3	4	»	7
Success . . . . .	35	7	5	47
	63	14	5	82

### *Conclusions.*

The points which I have made in this paper are as follows: That an examination for muscular asthenopia should include adduction and abduction at both extremities of the range of fusion. That the equilibrium test has great value but must be estimated in connection with the results of adduction and abduction. That the use of atropia is often essential to



correct diagnosis and that it does not in asthenopic cases prevent us from discovering the real capacity of the muscles.

That in certain cases of error in abduction there may be brought about a condition of debility of adduction which is a secondary effect, and is sometimes to be relieved by adductive prisms only and sometimes will admit of abductive prisms for the near and of adductive prisms for distance. That muscular insufficiency of the externi is more common than has been believed, and that it may long remain latent. That atropia is a great help in treating muscular asthenopia. That weak adductive prisms continuously worn have a notable influence in improving the strength of the muscles, and in bringing about the condition of repose of the visual axes. That the condition of repose is the object to be sought for in treating muscular asthenopia, and that this is not always identical with the state of equilibrium as indicated by the vertical diplopia test. That improvement in the strength of the muscles is not only to be gained by local appliances but is to be sought for in general constitutional measures. That the relative importance of local appliances and of constitutional measures will depend upon the degree, in which the muscular asthenopia is idiopathic or reflex.