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New York City

*Reprinted from*

*THE JOURNAL*
*of the American Medical Association*

*November 2, 1901*

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# STRABISMUS: ITS TREATMENT.*

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NEW YORK CITY.

If some one were good enough, or I might better say wise enough, to formulate a uniform set of tests for the detection and accurate measurement of strabismus, to be used by all observers in order to compare the results or the different methods of treatment, we might arrive at some valuable conclusions as to the best treatment of this affection. Again, a better understanding of the physiological action of the ocular muscles and, indeed, of physiology in general than now, as a rule, obtains would help elucidate the intricacies of the subject. The anatomy of the ocular muscles has been gone into thoroughly, but the physiological action of the ocular muscles and their intimate relation and co-relation in the use and movements of the eyes has been overlooked, or at least not kept in mind, it seems to me. In addition to a résumé of the subject of the treatment of strabismus, therefore, I shall call attention to these two points in particular, to-wit: The different tests for strabismus, and the physiology relating to the subject. In addition also I wish to call attention to the Panas operation for strabismus with table of cases.

* Read at the Fifty-second Annual Meeting of the American Medical Association, in the Section on Ophthalmology, and approved for publication by the Executive Committee of the Section: Drs J. A. Lippincott, Casey A. Wood and H. V. Würdemann.

*Physiology.*—Of course, this paper is entirely too brief to go into extended observations on the physiology of squint, but there are two or three points of importance I wish to bring before you for consideration. Incidentally, I may say, I include the insufficiency of the ocular muscles under these remarks, because an insufficiency is nothing but a latent squint, which may be easily forced into a manifest squint by the use of prisms —a practice which, I am sorry to say, is followed by some of my American colleagues. If we are to obtain the best results in the treatment of strabismus, either manifest or latent, we must bring to bear a knowledge of the physiology of the muscles and nerves in general, for an insufficiency or weakness of an ocular muscle differs in no particular in a physiological way from an insufficiency or weakness of any other voluntary striated muscle. For it is a well-established fact of physiology that the nerve-cells give out before the muscles. "It is undoubtedly of advantage to the body," says Warren P. Lombard,[1] "that the nerve-cells should fatigue before the muscles, for the muscles are thereby protected from overwork."

Now, in an insufficiency or weakness of any ocular muscle, the specialist—the ocular-muscle specialist, in particular—is prone to forget this general and most important physiological fact, and begins to treat the muscle itself locally by prescribing prisms or performing graduated tenotomies of the opposing muscles, or some other equally absurd procedure; failing to recognize that it is the nerve-cells which are fatigued, weak and at fault and in need of treatment. And this treatment, in the main, should be through increased nutrition, by means of tonics, rest, outdoor exercise, and by local treatment. The local treatment should consist of the proper correction of the error of refraction, and by having the patient turn the eyes forcibly in the direction of the weak muscle or muscles several times a day. Perhaps the local exercise of the weak muscles by means of prisms for a few minutes at a time each day may be a benefit in some cases, especially in cases that have been operated upon. In my own experience, however, this has not been very satisfactory. The practice of prescribing prisms for con-

1. An American Text-Book of Physiology, 1900, p. 78.

stant wear, except in paralytic squint, or in case of anatomical insufficiency (due either to faulty development, insertion or enervation of the muscle) should never be followed, because the weak muscle is made weaker and the strong muscle made stronger all the time, until the latent squint is made a manifest one. I have seen this occur more than once. The gentlemen who prescribe prisms for constant wear for insufficiency of the ocular muscles, and do not follow them up with stronger prisms, and, finally, with graduated tenotomies of the opposing stronger muscles, do not follow their treatment to a logical conclusion. For it has been demonstrated innumerable times that prisms, when worn with their bases over weak muscles and their apices over the opposing stronger muscles, make the strong stronger and the weak muscles weaker. In fact, increasing the strength of these prisms every few days or weeks, to bring out the extra strength of the strong muscles is the very method pursued by the men who perform graduated tenotomies. The gentlemen who prescribe prisms for physiological insufficiencies should follow up the first pair with the second, and a third and a fourth, if necessary, and finally perform tenotomies, or abandon the practice altogether, with the exception above noted, that is, in anatomical insufficiency or in paralysis of the ocular muscles.

Neither the constant wearing of prisms nor graduated tenotomies are the correct treatment in insufficiency of the ocular muscles or latent squint, but general treatment as above indicated, together with the correction of the refractive error, is the more rational procedure. This is certainly a common-sense method, and assists in the restoration of normal physiological action to the muscles through increased nutrition to the nerve cells. In weakness of the ocular muscles, just as in weakness of the muscles in general, we should, as Lombard well says, "Always bear in mind that though 'beef' is of use to the athlete the muscles are merely the servants, and can accomplish nothing if the master is sick. The nerve cells always give out before the muscles, and the man preparing for a contest should watch his nervous system more than his muscles."*

*Loc. cit., p. 76.

If the treatment of latent squint by means of prisms and graduated tenotomies is of little practical value, how much less so is the treatment of manifest squint by these means. In fact, the treatment of manifest squint by means of prisms, or by graduated tenotomies, has been abandoned by most oculists, and, at most, is but a sad memory to those who have tried it.

### TESTS FOR STRABISMUS AND THEIR RELATIVE VALUE BEFORE AND AFTER OPERATION.

Perhaps the most important step in the treatment of any disease is finding out the exact nature and extent of the disease; in other words, properly diagnosticating the disease. We have a number of tests for measuring squint, its nature and amount more or less exactly; but unfortunately, many of these tests can not be used in very young subjects, a class in which the majority of squint cases are observed. I shall describe at this point the principal tests for squint and their method of application, and after that give the technique of a routine examination bringing into requisition the different tests in the order of their importance, hoping thereby to establish what might be termed a standard examination for strabismus. Of course, this routine examination should not be made in exactly the same manner in every case, as there will be exceptional cases and individual peculiarities that will demand a modification to a greater or less extent of the method. But this routine examination should be followed as closely as possible in every case if we are to have a standard by which to compare the results of different treatments, and ultimately to select the best method of treatment as found out by this method of comparison. Uniformity of tests in these cases of squint is all important.

1. In latent squint or ocular insufficiency, the most reliable test in my experience is that made with ordinary prisms for adduction, abduction and sursumduction, etc., as follows:

To obtain the power of adduction, have the patient look at a candle-flame 20 feet distant, with both eyes open and any refractive error he may have properly corrected; then begin the test with the one degree prism, apex inward, that is, toward the nose and increase the strength of the prism until the patient sees double.

The strongest prism he can overcome without seeing double measures his adduction.

The abduction is obtained by placing the apex of the prism outward toward the temple, and gradually increasing it till the patient sees double; while the sursumduction right and left is obtained by placing the apex of the prism upward in front of the right and left eye respectively, and increasing the strength till the patient sees double.

J. M. Bannister, in testing 100 soldiers with normal eyes, found the average adductive power to be 14.1 degrees, abduction 7 degrees and sursumduction 2 to 4 degrees, the relative strength of adduction to abduction being two to one. Any wide deviation from this relation, especially when asthenopia is complained of, should be considered as an insufficiency and should receive treatment as indicated in the first part of this paper.

2. The Maddox-rod test for muscle insufficiency is practiced by many oculists, but in my experience it is not as reliable as the simple prism test. Besides, it has the same fault as the old Graefe test for muscle insufficiency, that of causing a diplopia as the first step in the test for insufficiency. This is a serious mistake as it takes away from the eye the stimulus for fusion of the images.

There are a number of tests for manifest squint, the principal ones of which I shall now describe:

1. *Perimeter Test.*—This is the best test for squint that we have, but unfortunately it can not be used accurately on patients under 5 or 6 years of age. As the majority of all squints are of a convergent nature and as about 40 per cent. occur in children under 6 years of age, it will be seen what a serious handicap this is. This test is made as follows:

Place the patient at the perimeter with the squinting eye in a line with the center of the arc, which should be in the horizontal position; have the patient look directly in front of him at a light or some small bright object 20 feet distant. Now carry a lighted candle along the arc of the instrument until the image of its flame occupies the center of the cornea of the squinting eye. Read on the arc the number of degree the candle is from the center of the arc. This is the degree of the

squint. For example, say the candle is carried to the twenty-degree mark on the arc when the image of its flame occupies the center of the cornea of the squinting eye. Twenty degrees is the amount of the squint, convergent or divergent as the case may be.

In vertical squint the arc of the perimeter should be placed in the vertical meridian, and while the patient looks in the distance the candle should be carried along the arc from its center until the image of its flame occupies the center of the cornea of the deviating eye. The position on the arc at which this happens indicates the amount in degrees of the squint.

To get the amount of the squint for the near point have the patient look at the center of the arc and move the candle along the arc in exactly the same way as before as in testing for the distance. The position on the arc at which the image of the candle flame occupies the center of the cornea of the squinting eye measures the amount of the squint. I have found the amount of the squint for the near point, in convergent squint, as a rule, to be two to five degrees greater than for the distance, due perhaps to an act of the accommodation.

2. *Cover or Screen Test.*—Have the patient look in the distance at some small object, as a candle flame; stand in front of the patient with the head lower than the patient's so as not to obstruct his view, cover the patient's good eye with a card and have the patient fix the candle flame with the squinting eye. Now place the strabometer of Laurence against the lower lid with the zero mark on a line directly under the center of the cornea of the uncovered eye; then remove the card from the good eye, when the patient will fix the candle with it and squint the bad eye as usual with him. Note on the strabometer the number of lines the center of the cornea of the squinting eye has moved from the zero mark. This gives the angle of the squint. The advantage of this test is that it can be applied in very young children.

3. Priestley Smith's *Tape Measure Test.*—This consists of two pieces of tape, one black and one colored, each one meter in length, and attached to a ring which can be slipped over the thumb. The colored tape is divided by lines into twelve parts, and numbered 5,

10, 15, etc., up to sixty degrees, ending in a small weight to keep it taut during measurements. The patient holds the end of the black tape against his face directly under the squinting eye, while the observer stands directly in front of him with the ring attached at the other end of the tape over his thumb or ophthalmoscope which he holds in front of his eye. The patient looks directly into the ophthalmoscope from which a light is reflected into the squinting eye. It will be noted that the image of the light from the ophthalmoscope will be to the other side of the center of the cornea in convergent squint and to the inside of the center of the cornea in divergent squint. The observer now takes hold of the colored tape at the ring, the edge of the hand being held towards the patient for the patient to look at, and lets the tape slide between his fingers, carrying it in a direction opposite to that in which the eye squints. Both eyes should follow the hand, and when the squinting eye has turned sufficiently for the image of the light from the ophthalmoscope to occupy the center of the cornea in that eye, stop the hand and note the distance it has moved along the tape. The number on the tape indicates the degree or angle of the squint.

This test is accurate enough for all practical purposes, and if the angle alpha is taken into account it is quite reliable. Then it has the great advantage that it can be used on very young children.

4. *Hirschberg's Test.*—This test consists in estimating the angle or amount of the squint from the position of the image of the candle flame reflected from the front of the eye. The candle is held about one foot in front of the patient who has both eyes open. The image of the flame in the eye that fixes will be in the center of the cornea, while the image on the squinting eye will be more or less eccentric according to the amount of the squint. With the average-sized pupil, 3.5 millimeters, if the image is half way between the center of the pupil and the pupillary margin the squint is less than 10 degrees; if at the pupillary margin, 12 to 15 degrees; if midway between the margin of the pupil and the corneal limbus about 25 degrees; if at the edge of the cornea 45 to 50 degrees; if out on the sclera 60 to 80 degrees.

Of course the angle alpha should be taken into consid-

eration in this test. This test is not very accurate but sufficiently so for practical work. It has the great advantage of application in very young subjects.

5. *Linear Measurement Test.*—This test is to be recommended only in case of false fixation. Have the patient look directly in front of him with both eyes open at a small object in the distance. Mark on the lower lids with ink a dot on a line with the outer border of the corneæ. Then measure the distance of the dots from the outer angle of the eye on each lid respectively. The difference in millimeters gives the amount of the squint.

6. *Prism Test.*—This test is applicable in those cases only where binocular vision exists. In recent cases where this condition sometimes obtains, and in cases where binocular vision has been brought about by treatment through improvement of the vision in the amblyopic eye and by bringing the images in the two eyes closer together (to get which latter condition this test itself is often employed), the prism test is of much value. It is applied as follows: Have the patient look at a candle flame 20 feet distant. Note the nature of the diplopia, if homonymous, cross or vertical; or if a combined deviation, by placing a red glass in front of one eye—the better one. In fact, it is often necessary to put a colored glass in front of one eye in order to establish a diplopia. Where the diplopia is present without a colored glass in front of the eye, the colored glass should be removed after the nature of the diplopia is established. The strength of the prism that is necessary to bring about single binocular vision divided by two represents the amount of the squint. For example, say we have a horizontal homonymous diplopia and that it requires a 20-degree prism apex inward to produce single binocular vision. This shows a convergent squint of 10 degrees. Again, say we have a horizontal cross diplopia which requires a 20-degree prism apex outward to cause single binocular vision. This shows a divergent squint of 10 degrees.

For establishing the fact whether single binocular vision does or does not exist, the prism test is invaluable. It is not altogether reliable as to the amount of the squint, exaggerated amounts being shown by it as compared with the perimeter test. I have seen the perim-

eter test show a squint of 10 degrees and the prism test immediately—in the same case—show 25 degrees. The cover or screen test also often gives an exaggerated amount of squint as compared with the perimeter test, especially in those cases where the squint is almost corrected and where binocular vision is present. There is a stimulus and a desire for fusion of the images in these cases, and when the screen is placed in front of one eye it at once eliminates this factor, and the result is the deviation of the eye behind the screen—to an exaggerated degree. With the perimeter test both eyes are left open and the desire for fusion of the images is not disturbed, and a more correct test is possible. Therefore, in every case where the perimeter test can be made it should be used in preference to any other test.

Hirschberg and Landolt have charts to hang on the wall by which the angle of the squint can be measured, but they are of service chiefly in paralytic squint (which is not under consideration in this paper), and in squint cases where binocular vision exists. In ordinary strabismus these tests are not very satisfactory.

The above tests should be tried in the order given, the perimeter test in all cases where it can be used, the screen test, the tape measure test, prism test, etc. Two or more of them at least should be tried, in order to ascertain accurately the amount of the squint.

### NON-OPERATIVE TREATMENT.

This consists in the use of atropin, atropin and glasses, the exclusion pad, the stereoscope, and bar-reading. It should be tried in every case of strasbismus before any operation is undertaken, and should be continued in as long as the squint continues to improve. When improvement ceases by this method then it is time to operate. The different steps of the non-operative treatment are as follows:

1. *The Exclusion Pad.*—This consists in tying a patch over the good eye in order to make the patient look at objects with the squinting eye, which usually has poor vision, especially if the squint is constant, unilateral and of long duration. In this way the patient does not lose the faculty of locating or fixing objects with the squinting eye, and at the same time maintains

and develops to a marked degree in some cases, as above quoted, the vision in the squinting eye. In cases of alternating squint, that is, where the patient first uses one eye, then the other, the faculties of vision and fixation are usually good and equal in each eye, being maintained as I believe simply by the use of first one eye and then the other. Therefore, following the plain lesson set by nature in these cases of alternating strabismus, we should, in cases of constant unilateral strabismus, where they can not or will not voluntarily use first one eye and then the other, make them do so by excluding the good eye from vision with a pad a certain number of minutes or hours each day.

2. *Mydriatics.*—A mydriatic, usually atropin, is used in the treatment of strabismus in order to paralyze the accommodation, and indirectly to act on the convergence. For, anything that relaxes the accommodation, relaxes at the same time and within certain limits the converging power of the eyes, the connection between the two functions being intimate.

The strength of the solution of atropin to be used depends on the age of the patient. In young children one-half to one grain to the ounce solution is quite strong enough. In older children (over 4 years of age) two to four grains to the ounce solution may be used. The parents are to be cautioned as to any poisonous symptoms of the drug, as flushed face, dry, hot skin, and dryness of the throat, and instructed to stop its use if these symptoms appear. Where an idiosyncrasy exists for the drug it can not be used at all; then some other mydriatic, as duboisin, must be substituted. One drop of the solution should be instilled into each eye twice a day and this to be kept up for one month, when it should be intermitted for that length of time. This should be repeated two or three or even four or five times according to the progress of the case. In divergent strabismus, atropin is contra-indicated, but may be used to ascertain the refractive error after which it should be discontinued.

3. *Glasses.*—Glasses help to correct convergent strabismus in two ways: 1. They improve the vision by correcting the refractive error, especially if astigmatism is present, if the squint is not of too long duration.

This gives a stimulus to use the eyes together. 2. The glasses, by taking the strain off of the ciliary muscle, lessen convergence in exactly the same way as mydriatics do by relaxing the accommodation. Many cases of convergent strabismus are relieved by the use of atropin and glasses alone if taken early. And, if the exclusion pad is used in addition, it greatly increases the chances of recovery without operation.

Usually in fitting glasses I do not use a mydriatic of any kind, but in strabismus cases I always use a mydriatic, because it helps directly to improve the squint and at the same time allows almost full correction to be given the patient to wear; not only this, but as most of these cases are under 6 years of age and can not be tested subjectively, that is, by the trial case and test card, it makes the objective test easier and more accurate.

When divergent strabismus is present in hypermetropic eyes, no glasses should be worn except to correct any astigmatism that may be present, because by relaxing the accommodation they increase the divergence. In myopia and myopic astigmatism the refractive error should be corrected fully, for the minus glasses stimulate the accommodative act, and in this way increase convergence and help overcome the divergence, especially in low degrees of divergence.

4. *Bar-Reading.*—In patients who are old enough, bar-reading is a useful adjunct in making the patient use the eyes together. It consists simply in holding a pencil or some other small object vertically before the eyes, and in front of a page of printed matter which the patient is reading. If the patient is not using the eyes together, but only the good one, when the line of vision in the good eye comes to the pencil the patient will stop reading or skip a word, or part of it, whereas, if the eyes are being used together, no such stop will take place, or missing any letter or part of a word. By persistent practice with this method the patient is often brought to use the eyes together, with effort at first but with facility after practice.

5. *Stereoscope.*—The stereoscope can not be used till the patient is 5 or 6 years of age. Its use gives the greatest stimulus to single binocular vision, that is, true form perception. By using special pictures, especially

geometrical figures, as truncated pyramids, the idea of perception of form in three dimensions is given.

There are a number of stereoscopes of special make to be had, but the ordinary stereoscope as bought in the market, if the prisms are removed and plus 6 D. spherical glasses substituted, answers all the purposes for the stereoscopic exercises. Especially is this so if the pictures of Dr. Kroll are used. These can be bought at any good optician's, the whole outfit, stereoscope and pictures, costing but two or three dollars. The patient should be instructed how to use it at the office, then should purchase one to be used at home. There is one sliding picture among Kroll's pictures. For fusing purposes this is admirable. At first the two sides can be brought close together until the eyes are able to fuse them as one; then the distance between them increased until the eyes are brought parallel, or almost so, and still fusing the images. This should be done for a few minutes at a time several times a day, the muscles not being exercised at any one time to the point of exhaustion.

### OPERATIVE TREATMENT.

There is a wide difference of opinion among surgeons as to the best method of operating for strabismus, also as to the proper age to operate. Individually, I think no operation for strabismus, with few exceptions, which I shall presently state, should be performed on children under 4 years of age. I am aware of the fact that not a few operators have operated for a strabismus as early as 2 years of age. This should not be done, but on two conditions: 1, where the squint is congenital, constant and not improved by the exclusion pad and atropin; 2, where false fixation exists. In the first condition I believe the squint is due to fault in the muscle itself, that is, improper development or insertion; and in the second, to marked amblyopia, which is not likely to improve by non-operative measures, but to get worse by delay. After 4 years of age, the proper time to operate is when the non-operative methods cease to improve the condition of the strabismus, but not under six months' time should be considered a fair trial in any case of the non-operative treatment, unless some special reason prevails.

The different operative procedures for the correction of strabismus may, in a general way, be divided into four classes. The technique of individual operators may vary to some extent, but the essential part of the operation remains the same.

1. Simple tenotomy of one muscle in the deviating eye, and later if effect enough is not obtained to perform advancement of the opposing muscle in the same eye.

2. Simple tenotomy of one muscle in the deviating eye, and later, if not enough effect, tenotomy of the like muscle in the opposite eye; if still not enough effect advancement of the opposing muscles first in the deviating eye and then in the opposite.

3. Advancement of the weak muscles in each eye (the external recti in convergent squint and the internal recti in divergent squint), after Landolt's method.

4. Stretching the strong muscles in each eye (internal recti in convergent squint and the external recti in divergent squint) and then tenotomy, after Panas' method.

Various devices for increasing or diminishing the effect of the operation have been recommended, such as a thread extending from one eye to the other and tied across the nose (Gruening) in cases of divergent squint; or a thread extending from the eyeball to the outer canthus in convergent squint after the operation has been performed. But these are only refinements of technique, and may or may not be used according to the desire of the operator.

In the first method of operating, where but one eye is operated upon, the assumption is that squint is a unilateral affection, and, therefore, the operations are confined to but one eye. I believe but a few members only of the profession follow such a procedure now, it being generally conceded that strabismus is a bilateral affection and not a unilateral one. Operations on one eye alone, therefore, should be discouraged, because they are performed under a misconception of the true nature of squint.

The second method of operating is followed by many surgeons, perhaps the majority of operations for strabismus come under this class. The method of performing

an ordinary tenotomy is so simple that it needs no description here. Suffice it to say that the effect of a tenotomy may be materially increased or diminished by the extent of the dissection of the capsule of Tenon at the time of the operation. The wider and deeper the separation of the capsule the greater the effect, and vice versa.

The third method of operating was recommended by Landolt many years ago. He advised advancement of the weak muscle in each eye without tenotomy of the opposing muscle.

Of all the different advancement operations, I like best what is known as the straight advancement. It is as follows:

Make a vertical incision about one-half inch in length in the conjunctiva, about one line from the margin of the cornea and just in front of the attachment of the muscle to be advanced; dissect up the conjunctiva from over the tendon of the muscle, then make a small hole in the capsule of Tenon and introduce a hook under the tendon of the muscle, and then a second hook, and expose the tendon of the muscle for about one-half inch by pulling the hooks in opposite directions. Remove one hook while one is left to hold the tendon away from the eyeball so as to introduce three needles with thread attached—in each instance from without inward through the tendon of the muscle about one millimeter or more, according to the effect desired, from the attachment of the tendon—one needle at the upper margin of the tendon, one at the lower, and one through the middle of the tendon. The conjunctiva may be picked up on the needles just before they are inserted into the tendon of the muscle so as to advance it along with the tendon. The tendon is now cut from its attachment. The center needle is inserted into the sclera about two millimeters from the corneal margin, directly forward from the old attachment of the tendon, coming out at the corneal limbus. Then the needles in the lower and upper margins of the tendon are respectively inserted into the sclera below and above and on a vertical line with the central suture. The center suture is tied first, the lower and upper ones at the same time (one by an assistant) so as not to cause torsion of the eye.

## TABLE 1.—RESULTS OF NON-OPERATIVE TREATMENT IN FORTY-SIX CASES TESTED UNDER A MYDRIATIC.

| No. | Date, Name, Age (years). | Diagnosis. | Deg. | Fixation | Duration. | Vision and Refraction. | Treatment. | Results. |
|---|---|---|---|---|---|---|---|---|
| 1 | Jan., 1900, G. L., 3½ | Convergence, constant, left | 20 | False | Since 8 months old. | Objective tests; R. H. 3 D., L. H. 4 D. | Atropin, occlusion pad, glasses. | May, 1901; convergence 10°; has not worn glasses all the time or followed other treatment steadily. |
| 2 | March, 1900, M. F., 3½ | Conv., const. some nystag. | 20 | True. | Unknown.. | Objective tests; R. 1 D. each | +2.75, R.; +3.50 L. Glasses, pad; atropin intolerable. | May, 1901; convergence 5°. |
| 3 | Oct., 1900, H. G., 25 | Conv., period. | 10 | " | 23 years | R. 20/20w. +1.25 D.; L. 20/20w. +1.50 D. +1.25 C. 165° | Glasses, pad, stereoscope | Single bin. vis. after 2 weeks, which holds May, 1901. |
| 4 | Feb., 1901, A. H., 5 | Convergence, constant, left | 30 | " | 1 year | Can not read; objective H. 7 D., R. C. H. Astg., L. 1 50 D. 50 C. 75°. | Glasses, atropin, pad. | May 5, 1901; patient gave up all treatment after first week because of illness; squint same as at first, 30°. |
| 5 | Jan., 1900, E. P., 6, R. 18 | Divergence, alternating. | 5 | " | 1 year | R. 20/50; 20/30w. −.75 D ⊃ −.50 C. 165°, L. 20/50; 20/10 w. −1 D. ⊃ .50 C. 15° | Glasses, stereoscope | May, 1901; condition unchanged; gave up all treatment after 3 months |
| 6 | June, 1900, M. C., 30 | Diverg., const. left | 15 | " | Unknown.. | R. 20/200; 20/40w. −5.50 D. ⊃ −1.50 C. 45°; L. 20/200; 20/50w. −5.50 D. ⊃ 2.50 C. 5°. | Glasses, pad, stereoscope, declined operation. | Slight improvement. |
| 7 | June, 1900, J. Y. B., 29 | Diverg., alter. | 5 | " | Unknown.. | R. 20/15; 20/15 +w. +1 D., L. 20/15; 20/15 +w. +1 D. | Tonics, stereoscope | One month later single bin. vis.; not seen since. |
| 8 | Sept., 1900, H. M., 28 | Div., per., alt., | 5 | " | Unknown. | R. 20/20; 20/20 +w. + .50 C. 90°, L. 20/20; 20/20+w. +.50 C. 90° | Glasses, tonics, declined opera | Mar., 1901; divergence 8°. |
| 9 | Oct., 1900, J. C. N., 35 | Diverg., const. left. | 30 | " | Since 4 yr. old; operat. 20 yr. | R. 10/200; 20/200w. +4 C. 90°, L. 20/40; 20/20w. +1.50 D ⊃ +2 C. 90°. | Glasses, declined second opera | Condition unchanged. |
| 10 | Dec., 1900, M. A. S., 38 | Diverg., alternating. | 5 | " | Unknown.. | R. 20/15; 20/10w. +.75 D., L. 20/15; 20/10w. +.50 D. ⊃ +.25 C. 90° | Glasses, tonics, stereoscope | May, 1901; single bin. vis. all the time; no diplopia as before treatment. |
| 11 | Sept., 1900, A. B., 3 | Conv., const. right. | 5 | " | 4 years | R. 20/200; 20/200w. +1 D. ⊃ +3 C. 100°, L. 20/30; 20/20w. +2.50 D. ⊃ 1.25 C. 85°. | Glasses, pad, atropin. | Oct., 1900; parallelism; 5, 14, 1901, parallelism, bin. vis. |
| 12 | Sept., 1900, J. G., 14 | As above | 20 | " | 12 years.. | R. 10/200; 20/200w. 3+D., L. 20/200; 20/30w. 2+D. | " " " | Oct. 11, 1900; eyes parallel for distance, but 5° conv. for near; not seen since. |
| 13 | Sept., 1900, N. M., 3 | Conv., const. | 20 | " | 1 year | Objective tests; H. 3.50 each. | " " " | May 14; eyes parallel. |
| 14 | Sept., 1900, C. K., 6 | Conv., const. right. | 40 | " | 5 years | Objective tests; R. +2 D. ⊃ +3 C. 75°, L. +2 D. ⊃ +3 C. 105°. | " " " | May 14, 1901; conv. 35°; has not followed treatment; advised operation. |
| 15 | Sept., 1900, A. C., 20 | As above | 20 | " | Since a baby | R. 20/40; 20/20w. +1 D. ⊃ +.50 C. 90°, L. 20/50; 20/30w. +1 D. ⊃ +1 C. 105°. | " " " | Oct. 27, 1900; conv. 25°; saw but once after giving glasses. |
| 16 | Oct., 1900, A. B., 11 | As above | 15 | " | 7 years | R. 20/40; 20/20 w. +4.50 D. ⊃ +2 C. 90°, L. 20/20; 20/20w. +4.50 D. ⊃ +.75 C. 90°. | " " " | May, 14, 1901; single bin. vis. |
| 17 | Oct., 1900, B. C., 12 | As above | 15 | " | Since baby | R. 20/200; 20/70w. +2 C. 90 ⊃ −1 C. 180°, L. 20/100; 20/40w. +2 C. 75°. | " " " | Dec. 18, 1901; conv. 10°; not seen since. |
| 18 | Oct., 1900, J. B., 17 | Conv., const. left. | 5 | " | 2 years | R. 20/20; 20/20 +w. +2.50 D. ⊃ +.25 C. 180°, L. 20/200; 20/30w. +1.75 D. ⊃ +1.50 C. 180°. | " " " | Dec. 18, 1900; single bin. vis.; May 14, 1901; single binocular vision. |
| 19 | Oct., 1900, W. K., 10 | Conv., const. right. | 15 | " | 1 year.. | Can not read; objective tests; R. +7 D. ⊃ +1.50 C. 75°, L. +7 D. ⊃ +1.50 C. 105°. | " " " | Dec. 1, 1900; convergence 5°; not seen since. |
| 20 | Jan., 1901, W. McG., 6 | As above | 50 | " | 1 year. | Objective tests; R. +2 D. ⊃ +2 C. 90°, L. +2 D. = +2 C. 90° | " " " | May 14; convergence 20°. |
| 21 | Feb., 1900, F. C., 13 | Converg., periodic. | 5 | " | Since baby | R. 10/200; 20/30w. +2.50 D. ⊃ +4.50 C. 80°, L. 20/70; 20/50w. +2.50 D. ⊃ +4 C. 80°. | Glasses | May 16; eyes parallel; binocular vision. |
| 22 | Feb., 1901, M. O'N., 11 | Conv., altern'g | 15 | " | Since baby | R. 20/20; 20/20+w. +1.25 D., L. 20/20; 20/20+w. +1.25 D.. | Glasses, pad, atropin. | May 16; convergence 5°; sursumvergence 5°. |
| 23 | Feb., 1901, J. S., 8 | Conv., const. right. | 20 | " | 4 years | R. 20/50; 20/40w. +2 D. ⊃ +2.50 C 90°, L. 20/50; 20/40w. +2 D. ⊃ +2.50 C. 90°. | " " " | May 2; convergence 5°. |
| 24 | Feb., 1901, B. S., 3½ | Conv., const. l. | 40 | " with effort | 6 months | Objective tests; +4 D. each eye | " " " | April 30; convergence 25°. |
| 25 | Feb., 1901, J. K., 5 | Conv., const. r. | 15 | True. | 2 days. | Objective tests; R. +3 D., L. +2.50 D. | " " " | May 2; parallelism. |
| 26 | Feb., 1901, T. L., 3 | Conv., altern'g | 20 | " | 8 months | Objective tests; +3.50 D. each eye. | " " " | May 16; parallelism. |
| 27 | March, 1901, L. L., 4 | Conv., const. l. | 15 | " | 8 months | Objective tests; +2.50 D. ⊃ +1 C. 90°, +2 D. ⊃ +1.50 C. 90° | " " " | May 16; convergence 10°. |
| 28 | March, 1901, J. H., 7 | Conv., nystag. mus.* | 5 | False | Since birth | R. 20/200; 20/70w. +4 D., L. 4/200; central choroiditis and myopia 8 D. | Atropin, glasses, +4 D. R., plain left. | May 14; parallelism, both uncovered and with glasses on: left convergence 50° when right is covered. |
| 29 | March, 1901, F. R., 7 | Conv., const. l. | 10 | True. | 1 year. | Objective tests; +6 D. each eye. | Glasses, pad, atropin | May 16; parallelism; single binocular vision. |
| 30 | March, 1901, M. G., 5 | As above | 15 | " | 4 days. | Objective tests; R. +1.75 D., L. +2.25. | " " " | May 16; parallelism. |
| 31 | March, 1901, E. H., 9 | Conv., periodic | 15 | " | Since a baby | R. 4/200; 20/100w. +7 D., L. 7/200; 20/50w. +7 D. | " " " | May 16; parallelism; single binocular vision. |
| 32 | March, 1900, H. J., 18 | Conv., const. l. | 15 | " | 13 years | R. 20/50; 20/30w. +4.50 D. +.50 C. 90°, L. 12/200; 20/100w. +3 D. .50 C. 90°. | " " " | May 24, 1900; convergence 2°. |
| 33 | March, 1900, M. W., 13 | As above | 10 | " | 7 years | R. 20/200; 20/30w. +2.50 D., L. 15/200; 20/70w. +1.50 D. ⊃ +4 C. 75°. | " " bar-reading | May, 1900; eyes parallel; May, 1901; eyes parallel; single binocular vision. |
| 34 | March, 1900, A. C., 3 | Conv., const. r. | 40 | " | 1 year | Object tests; R. H. 6 D., L. H. 5 D. | Glasses, pad, atropin; atropin discontinued on advt. of poisoning | June, 1900; convergence 5°; not seen since. |
| 35 | April, 1900, E. M., 30 | As above | 15 | " | 2 years | R. 20/100; 20/70w. +3 D. ⊃ +2.50 C. 90°, L. 20/100; 20/40w. +3.50 D. +1 C. 90°. | G., pad, bar-reading, stereoscope | May 8, 1901; sing. bin. vis. distance, not for near. |
| 36 | May, 1900, E. S., 7 | As above | 30 | " | 4 years | R. 20/200; 20/200w +4.50 D., L. 20/30; 20/20w. +3.50 D. | Glasses, pad, atropin | After 1 month conv. 15°; not seen since. |
| 37 | May, 1900, A. G., 9 | Conv., const. l. | 40 | " | 8½ years | R. 20/30; 20/30w. +3 D. +1 C. 75°, L. 20/40; 20/40w. +2 D. +4 C. 100°. | " " " | Aug. 23, 1900; convergence 30°; not seen since. |
| 38 | May, 1900, R. S., 3½ | Conv., const. l. | 15 | " | 1 month. | Objective tests; R. H. 3 D., L. H. 4 D. | " " " | Mar. 4, 1901; eyes parallel. |
| 39 | July, 1900, R. H., 4 | Conv., altern'g | 10 | " | 3 months | Objective tests; R. H. 3. D., L. H. 3.50 D. | Glasses, atropin | Eyes parallel after 3 mos. for distance; not seen since. |
| 40 | July, 1900, J. O'C., 12 | Conv., alt.; usually squints; | 45 | " | Since an infant. | R. 20/50; 20/30w. +.75 D. +1.50 C. 90°, L. 20/20; 20/20w +1.25 D. +.75 C. 90°. | Atropin, pad, glasses, bar-reading, stereoscope. | Aug. 28, 1900; parallel for dist., 5° conv. near; Oct. 11, sing. bin. vis.; May 14, 1901, sing. bin. vis. for all dist. |
| 41 | March, 1901, M. B., 6 | Conv., const. l. | 15 | " | 2½ years | Objective tests; R. +3 D. +.50 C. 90°, L. +3 D. +1 C. 90° | Glasses, pad, atropin | May 16; parallelism; binocular vision. |
| 42 | March, 1901, M. B., 16 | As above | 15 | " | 2 years | R. 20/30; 20/20w. +3 D., L. 20/100; 20/30w. +3.50 D. | [C. 75°. | May 20; parallelism. |
| 43 | June, 1900, L. McG., 12 | Divergence, alternating. | 12 | " | 2 years | R. 20/200; 20/50w. −6 D. −1.50 C. 170°, L. 18/200; 20/50w. 6 D. 2 C. 15°. | Glasses, stereoscope | May, 1901; divergence 8°; seen but twice. |
| 44 | July, 1900, L. P., 17 | Diver., const., left | 5 | " | 4 months | R. 10/200; 20/20w. −4.50 D., L. 5/200; 20/20w. −9 D | Glasses, pad, bar-reading, stereoscope | May 14, 1901; single bin. vis. with glasses, 5° divergence without. |
| 45 | Oct., 1900, M. F., 6 | Diver., cons., r. | 10 | " | Unknown. | Objective tests; R. 3 D.−3 C. 15°, L. 2.50 C. 165 | Glasses, pad | May 14, 1901; divergence 2°. |
| 46 | Sept., 1900, J. H. C., 28 | Conv., cons., l. | 5 | " | Since a baby | R. 20/40; 20/20w. +5.50 D., L. 20/200; 20/70w. +5.50 D | " " " | Unimproved. |

* When right is covered left converges 50°. Both uncovered perimeter shows 5° convergence left

## TABLE 2.—RESULTS OF PANAS' OPERATION COMBINED WITH NON-OPERATIVE TREATMENT IN THIRTY-FOUR CASES.

| No. | Date, Name, Age (year). | Diagnosis. | Degree. | Fixation. | Duration. | Vision and Refraction Under Atropin. | Treatment. | Results. |
|---|---|---|---|---|---|---|---|---|
| 1 | Sept., 1900, H. C. K., 23 | Convergence constantly left. | 60 | True | Since a baby | R. 20/70; 20/20w. +1.50 D., L. 20/200; 20/100 +w. +1.50 D ⊃ +2.50 C. 105°. | Atropin, glasses, pad, Panas' operation, stereoscope, bar-reading | Triplopia immediately after; 6 weeks later single bin. vis.; V. 20/40 in squinting eye. |
| 2 | Sept., 1900, A. McC., 4 | Convergence constantly right. | 40 | " | Since a baby | Objective tests, R. H. 3 D., L. H. 2 D | Atropin, glasses, pad, Panas' operation | Over-effect 15° immediate; 2 weeks later parallelism, which holds April, 1901. |
| 3 | Nov., 1900, B. J., 10 | Convergence constantly left. | 35 | " | 5½ years | R. 20/70; 20/50w. +2 D. ⊃ 1.50 C. 80°, L. 20/200; 20/100w. +2 D. ⊃ +1.50 C. 100°. | Glasses 15 mo. altogether, pad, atropin, Panas' opera., stereoscope, bar-reading | Immediate effect 5° divergence; after 1 day single bin vis., which holds April, 1901. |
| 4 | Jan., 1901, T. B., 22 | Conv. and sursumver. const. left. | 30 | " | 15 years | R. 20/100; 20/20w. +4 D. ⊃ +.75 C. 35°, L. 20/200; 20/50 w. +4.50 C. +.75 C. 125°. | Glasses, pad, atropin, Panas' operation, stereoscope. | Immediate effect, diver. 20°, sursumvergence 25°; May, 1901; sing. bin. vis. for distance, not near point. |
| 5 | Apr. 13, 1900, I. L., 15 | Divergence alternating. | 5 | " | 6 months | R. 20/20; 20/20 +w. +.75, L. 20/20; 20/20 +w. +1 D. | Tonics, glasses, Panas' opera, Dec. 13 | 30° over-effect at first; single binocular vision 6 weeks later, and still holds. |
| 6 | Dec. 5, 1899, L. J. B., 30 | As above | 15 | " | Since a child | R. 20/15−w. +.25 D. ⊃ +25 C. 180°, L. 20/15−w. + .25 D. ⊃ +.25 C. 180°. | Glasses, Panas' operation Jan. 23, 1901 | 20° over-effect at first; single binocular vision 4 months later, holds. |
| 7 | Mar. 29, 1900, N. V., 8 | Convergence constant left. | 20 | " | 2 years | R. 20/20; 20/20w. +3 D. ⊃ +.75 C. 90°, L. 20/200; 20/40 w. +1 D. ⊃ +2 C. 90°. | Glasses, pad, atropin, reduced squint to 15° Aug. 31; Panas' operation. | Immediate over-effect 20°; Oct. 6, over-effect 10°; April 20, 1901, over-effect 10°; to be operated on again. |
| 8 | June 29, 1900, W. D., 23 | As above | 20 | " | 20 years | R. 20/20; 20/20w. +2 D. ⊃ +1.25 C. 90°, L. 20/30; 20/20w. +3.50 D. ⊃ +1 C. 180°. | Glasses, pad, atropin, Panas' operation July 11. | Parallel at once; single bin vis.; Mar. 23, 1901, sing. bin. vis.; vision 20/20 in each eye. |
| 9 | July 5, 1900, A. S., 6 | As above | 25 | " | 1 year. | R. 20/200; 20/20 −w. +3 D., L. 10/200; 20/200w. +3.50 D. [C. 75°. | Glass, pad, atropin, reduced squint to 15°; Jan. 16, 1901, Panas' operation | Parallel at once; single bin vis.; Mar. 23, 1901, sing. bin. vis.; vision 20/20 in each eye. |
| 10 | Dec., 1900, J. C., 19 | Diver. cons. right. | 20 | " | Since child | R. 4/200; 20/70w. −11 D., L. 20/20; 20/20w. −.50 D. 75 | Glasses, pad, Panas' operation. | Immediate over-effect 30°; April, 1901, parallelism. |
| 11 | July, 1901, E. S., 11 | Diver. preferably mostly right eye | 30 | " | 10 years.. | R. 20/30; 20/20w. −1.50 D., L. 20/40; 20/20w. −1 D | Glasses, Panas' operation, July; also in November on same muscles | Immediately after 2d opera., diverg. 10°, but homo. diplopia 6°; May, '01, sing bin. vis. with or without glasses. |
| 12 | Dec., 1900, W. T., 16 | Divergence constant left. | 25 | " | Since a baby | R. 20/20; 20/15w. +.75 D., L. 20/30; 20/30 +w. +.75 D. | Panas' Operation. | Immediate over-effect 20°; 1 week later sing. bin. vis., which holds, May, 1901, without glasses; patient has angle alpha 20°, giving appearance of divergence. |
| 13 | May, 1900, A. G., 9 | Convergence constant left. | 40 | " | 8½ years | R. 20/30; 20/30 +w. +3 D. ⊃ 1 C. +75°, L. 20/40; 20/40 +w. +2 D ⊃ +4 C. 100°. | Atropin, glasses, Panas' operation | October, 1900, parallelism. |
| 14 | June, 1900, J. B., 1½ | As above | 40 Rt. 15 Lt. | False | Since 1 mo. of age. | Objective test. R. H. 5, L. H. 4 | Atropin, Panas' operation | Parallelism immediate after operation, which held for a month; not seen since. |
| 15 | Oct., 1900, J. K., 4 | As above | 35 | True | Since a baby | Can not read objective tests, H. 4 D. each; ordered +3.50 D. each. | Glasses 10 months before I saw her; atropin, pad, Panas' operation | Immediate effect 5° conv.; patient stopped all treatment 2 weeks after operation, not wearing glasses even; May, 1901, conv. 10°. |
| 16 | Mar., 1900, A. D., 38 | Convergence constant right. | 60 Lt. 10 Lt. | False right | 12 years | R. 8/20 not imp., L. 4/200; 20/50w. −12 D. ⊃ 1.50 C. 180°. | Glasses, R −10 D., L. −10 D. ⊃ 50 C. 180°, pad, Panas' operation. | May 8, 1901, R. V. ⊃ 20/50, L. V. = 20/50; single binocular vision. |
| 17 | Apr. 1, 1900, J. S., 5 | As above | 50 | False | 3 years | Objective tests, H. 5.50 D. each eye | Panas' operation April, 1900; again Mar., 1901. | Over-effect 10°, which remained till March, 1901, when Panas opera. on external recti; May, 1902, eyes paral. |
| 18 | Apr., 1900, J. B., 23 | Convergence constant left. | 60 | True | 20 years | R. 20/200; 20/20w +5.50 D ⊃ +1 C. 90°, L. 2/200; 20/200w. +5.50 D ⊃ +2 C. 105°. | Glasses, atropin, pad, Panas' operation. | May 31, 1901, parallel for distance, 5° convergence for near point. |
| 19 | May, 1900, C. J., 5 | Convergence constant right | 20 | False | 4 years | Objective tests, R. unclean cataract, L. Hastig Gr., nystagmus. | R. plain glass, L. +2 D. ⊃ +2 C. 90°, atropin. Panas' operation. | May, 1901, eyes parallel. |
| 20 | Aug., 1900, D. P., 16 | Conv. cons. left. | 30 | " | Unknown | R. 20/30; 20/20w. +2.50 D., L. 3/200; 20/20w. +3.50 D. | Glasses, pad, atropin, Panas' operation. | Aug. 25, 1900, eyes parallel. |
| 21 | Aug., 1900, C. H., 10 | As above | 25 | True | 5 years | R. 20/70; 20/40w. +2.50 ⊃ +2 C. 90°, L. 20/200; 20/20 w. +2.50 ⊃ +2 C. 105°. | As above.. | May 14, 1901, single binocular vision with and without glasses. |
| 22 | Sept., 1900, S. M., 13 | As above | 35 | " | Since a baby | R. 20/200; 20/20w +6.50 D., L. 20/200; 20/30w. +7 D. | Atropin, pad, glasses, Panas' operation by Dr. Maneor (house surgeon). | Immediate effect after operation, conv., changed to divergence 30°; advanced both internal recti, one after the other; conv. 15°; ultimate diver. 10°. |
| 23 | Sept., 1900, T. G., 6 | Convergence constant right | 20 | " | Since a baby | Objective tests, H. 3 D. each. | Atropin, pad, glasses, Panas' operation. | Immediate over-effect 30°; April 23, 1901, parallelism; May 14, 1901, parallelism. |
| 24 | Oct., 1900, E. H., 17 | Convergence constant left. | 35 | " | Since a baby | R. 20/200; 20/30w. +4 D. ⊃ +2 C., 75°, L. 15/200; 20/70w. +4 D. ⊃ +2 C. 105°. | " " " " " | May 14, 1901, binocular vision. |
| 25 | Oct., 1900, M. G., 22 | Convergence constant right. | 25 | " | Since a baby | R. 20/70; 20/40w. +1.50 D. ⊃ +3 C. 80°, L. 20/40; 20/30w. +1.50 D. ⊃ +3 C. 105°. | " " " " " | April 3, 1901, eyes parallel. |
| 26 | Oct., 1900, A. F., 10 | Convergence constant left. | 60 | " | 7 years | R. 20/20; 20/30w. +1.25 D., L. 2/200; 4/20w. +3 C. 90°. | " " " " " | Parallelism. |
| 27 | Sept., 1900, W. G., 4 | Convergence constant right. | 30 | " | 2 years | Objective tests, R. +2.50 ⊃ +3 C. 105°, L. +2.50 ⊃ +3 C. 75°. | " " " " " | Dec. 8, 1900, convergence 10°; not seen since. |
| 28 | Oct., 1900, E. N., 7 | As above | 40 | " | 3 years | R. 20/100; 20/20w. +3.50 D. ⊃ 2.50 C. 75°, L. 20/70; 20/30 +5 D. | " " " " " | May 18, 1901, eyes parallel; single binocular vision. |
| 29 | Oct., 1900, E. B., 15 | As above | 60 | False | 12 years | R. 3/200; 10/200w. +3 D. ⊃ +1.25 C. 75°, L. 20/20; 20/20 +w. +3 D ⊃ +1.25 C. 120°. | " " " " " | April 18, 1901, eyes parallel. |
| 30 | Nov., 1900, M. L., 9 | As above | 15 | True | 7 years | Can not read objective tests, R. +4 D. ⊃ +.50 C. 90°, L. +4 D. ⊃ +.50 C. 90°. | " " " " " | May 16, 1901, parallelism distance; 5° conv. near. |
| 31 | Jan., 1901, M. K., 6 | Convergence constant left. | 20 | " | 3 years | Can not read objective tests, R. +2.50 D. ⊃ +.50 C. 105°, L. +2.50 D. ⊃ +1.50 C 90°. | " " " " " | Immediate over-effect 20°; May 14, divergence 10°. |
| 32 | Feb., 1901, M. C., 11 | Convergence constant. | 25 | False | 7 years | R. 4/200; 20/200w. +2 D. ⊃ +.75 C. 75°, L. 20/20; 20/20 +w. +1.50 ⊃ +.75 C. 105°. | " " " " " | May 16, divergence 10°. |
| 33 | Mar., 1901, D. P., 25 | Conv. both eyes; head carried to L. | 40 Rt. 10 Lt. | " | Since a baby | R. 3/200; 3/200w. +2.50 D., L. 20/50; 20/20w. +.75 D. ⊃ +25 C. 90°. | " " " " " | May 16, parallelism. |
| 34 | June, 1900, E. H., 4 | Conv. constant. | | " | Since baby | Objective tests, +.75 C. 90° each. | Glasses, Panas' operation | Parallelism without glasses; binocular vision. |

## TABLE 3.—RESULTS OF SIMPLE TENOTOMIES COMBINED WITH NON-OPERATIVE TREATMENT IN THREE CASES.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | Sept., 1900, N. H., 20 | Convergence constant left. | 5 | True | Since a baby | R. 20/40; 20/20w. +1.50 C. 90°—.50 D., L. 20/200; 20/70w. +2.50 C. 90°. | Had 3 or 4 operations before coming to me; atropin, glasses, pad, stereoscope, bar-reading. | After 5 weeks' treatment single binocular vision, which still holds, May, 1901. |
| 2 | Nov., 1900, L. B. L., 30 | Convergence constant right. | 5 | " | 21 years | R. 20/200; 20/30w. +1.50 D. +1 C. 95°, L. 20/70; 20/15w. +.75 D. +1 C. 90°. | Operation, both eyes, at 8 yr. by another surgeon, glasses; by me, new glasses, pad, stereoscope, bar-reading. | One week, single binocular vision, which holds May 8, 1901; perfect comfort. |
| 3 | Sept., 1900, H. F., 17 | As above | 25 | " | 15 years | R. 20/70; 20/20w. +3 D., L. 20/70; 20/20w. +3 D. | Had 2 oper' 3 yr. ago, atropin, pad, glasses | May 14, 1901, eyes parallel; binocular vision. |

Both eyes should be bandaged for fifteen hours; after which time it has been my practice to remove the bandage permanently, putting on iced cloths ior one-half hour four times a day to relieve the congestion. In convergent squint if there is an under-effect I instill atropin and have the patient wear glasses; if an over-effect, I leave off the glasses and do not use atropin. Landolt advises to keep the eyes bandaged for a week, the patient in bed and quiet. Dr. Wooton, at the Manhattan Eye and Ear Hospital, who does essentially the same operation as Landolt, follows his plan of keeping the eyes bandaged for a week. Dr. Wooton reports favorable results from fifteen operations, only two being failures. My experience with simple advancement, without tenotomy of the opposing muscle, is limited and unfavorable. In no case was the effect sufficient. In a recent discussion of this subject at the New York Academy of Medicine, Dr. Gruening said he had tried Landolt's method, and had put cases at Dr. Landolt's disposal when he visited this country, but that in none of the cases was the effect of the operation sufficient. The ultimate results by this operation are not satisfactory because of not enough effect.

The fourth method of operating is after Panas' suggestion. He operates on both eyes in every instance. In convergent squint on the internal recti, in divergent squint on the external recti. The tenotomy is performed in the usual way with this important variation, that the muscle to be operated upon is stretched before cutting. For example, in convergent squint the hook is placed under the tendon of first one internal rectus and then the other, and the eye turned forcibly outward until the cornea is entirely hidden under the external canthus, then the tendon is separated as in ordinary tenotomy. In divergent squint each external rectus is stretched by turning the eye forcibly inward till the cornea is hidden under the internal canthus, then simple tenotomy is performed. Both eyes are bandaged for twelve to fifteen hours, when the bandage is removed and iced cloths applied. In convergent squint, if the effect is insufficient, atropin is instilled and glasses then worn; if over-effect, glasses are left off and no atropin used. In divergent squint, if under-effect,

glasses are put on; if over-effect, glasses are left off and atropin instilled.

The immediate result, as a rule, after a Panas operation is an over-effect, varying from five to twenty-five or thirty degrees. This rapidly disappears, however, till within a few days to a few weeks, in exceptional cases months, the eyes become parallel, and in the great majority of cases remain so; many of the cases securing single binocular vision by one operation.

To any one performing Panas' operation for the first time the immediate result is somewhat alarming. I must confess I was reluctant to undertake the operation until I saw the good results obtained by Dr. Roosa in eyes operated upon by this method. Especially was I fearful of over-effect in small degrees of squint. My experience with the operation, however, has taught me, contradictory as it may seem, that in low degrees of squint we are not so apt to get over-effect as in the higher degrees. It was puzzling to me at first to get a satisfactory explanation of this effect—opposite to what was naturally to be expected. After observing a number of cases and investigating the physiology of muscle and nerve stretching the following explanation was suggested: In cases of very marked squint, especially where there is a false fixation, with limitation of motion, where there is contracture and actual shortening of the muscle, the force that it requires to stretch such a muscle until the cornea is hidden in the opposite canthus is considerable, and the nerve fibers and muscle cells may be stretched to such an extent as to cause temporary paralysis, which it may take days, or, in exceptional cases, weeks or months even to recover from. On the other hand, where there is but a small or moderate degree of squint, the stretching does not have the paralyzing effect to near the same extent as in cases with excessive squint.

W. P. Lombard, in speaking upon the irritability of nerves and muscles, has this to say: "The irritability of muscles is likewise increased by moderate stretching and destroyed if it be excessive. Surgically, the stretching of nerves is sometimes employed to destroy their excitability. Slight stretching heightens their excitability, and even quite vigorous stretching has only a temporary

depressing effect unless it be carried to the point of doing positive injury to the axis-cylinder and of causing degeneration. As nerves have the power to regenerate, they may recover from even such an injury."*

Again, in relation to the conductivity of the nerves and muscles, Lombard says: "The power of conduction appears to return before irritability, and may be observed first at the end of the third week. Apparently sensation is recovered before the power of making voluntary movements; this difference may well be due, not to any essential difference between sensory and motor fibers, but to the fact that extra time is required for the motor fibers to make connection with the muscles."

It is unnecessary to say that some judgment must be used in determining the amount of force to be used in stretching a muscle. If the cornea can not be hidden in the canthus without causing actual damage to the muscle fibers then it should not be carried so far. Of course, experience here, as in every other operation, counts for much in the successful result. Panas tested the strength of the ocular muscles thoroughly on the dead subject before performing the operation on the living, and found that the muscles could withstand great strain before breaking. Another factor in producing an over-effect in cases where excessive squint exists is the marked amblyopia usually present in such cases. The desire for fusion of the images is not so great in such cases as where the vision is nearer equal in the two eyes, as it often is in lesser degrees of squint. This factor, however, figures in the results obtained after any method of operating for squint, and is not peculiar to Panas' method.

In the cases which have not been successful after Panas' operation, over-effect has not resulted much more frequently than under-effect. Neither has the fear of ultimate over-effect, as predicted by the opponents of the Panas operation, been fulfilled.

There is one other operation of which I have not spoken so far, because I have had no experience with it. This is the knuckling operation of Savage and Valk. In the operation the muscle to be advanced, the weak one, is bared of conjunctiva and capsule of Tenon for

* Loc. cit., p. 78.

some distance back of its attachment. Then a small speculum (Valk's), somewhat like the ordinary lid speculum, is placed under the muscle. A threaded needle is then so introduced that when the thread is drawn taut a knuckle is formed in the tendon, thus shortening the muscle. A longer or shorter knuckle is taken in the tendon according to the effect desired. When the effect is not great enough, Dr. Valk, I believe, performs simple tenotomy of the opposing muscle. Valk claims 100 per cent. of cures by this method, that is, parallelism. I think this too large a percentage to claim for any operation, as no operation yet devised to correct squint has proved entirely satisfactory. Individually, I prefer Panas' method to any other, and believe it will win for itself a permanent place in ophthalmic surgery.

RESULTS.

*Non-Operative Treatment.*—In February, 1900, I reported results of treatment in private practice of 40 cases of convergent strabismus by the non-operative method. In these 40 cases 25 per cent. were cured; that is, secured parallelism, and single binocular vision was obtained in 7.5 per cent. of the cases. While in hospital practice, in 262 cases, where glasses alone were tried, and these not faithfully, only about 5 per cent. of the cases were cured.

Since February, 1900, I have given special attention to the non-operative method of treatment of squint in private practice and at the clinic of Drs. Lewis and Van Fleet, at the Manhattan Eye and Ear Hospital, where all of the squint cases, through the courtesy of Drs. Van Fleet and Lewis, came under my personal care. I have also, during that period, been performing Panas' operation, when any operation was necessary, in my private practice, 11 cases in all. At the clinic, Drs. Roosa, Van Fleet, Meanor and myself have operated by the Panas method on 23 cases. Excluding cases which came but once or twice, or have been lost from observation, there are 83 cases upon which to make a final report as to results of treatment, non-operative and operative. Three of these cases had been operated upon by simple tenotomy some years before coming under my care without securing parallelism. By means of non-operative treatment I gave two of them single binocular vision

and one of them binocular vision, and have included them in a separate table to show the benefit of non-operative treatment in securing a perfect result after operative treatment had failed. From observing Table No. 1 it will be seen by the non-operative method of treatment 23 cases, or 28.75 per cent., were cured, that is, secured parallelism. Eleven of the 23 cases, or 13.75 per cent. secured single binocular vision; and 3 cases, or 3.75 per cent., secured binocular vision; 17 cases, or 21.25 per cent., were improved, some a little and some very much; 4 cases, or 5 per cent., were unimproved, but these did not follow treatment as directed; finally 2 cases, or 2.5 per cent., became worse while under treatment. Thirty-four cases, or 42.5 per cent., came to operation, the results of which are shown in Table No. 2.

Thirty-seven of the 46 cases in Table No. 1 had convergent squint and 9 divergent. Hypermetropia was present in 41 of the cases and myopia in 5.

By means of the non-operative treatment alone 28.75 per cent. of the cases were cured, and with further continuance of the treatment 30 per cent. at least should secure parallelism. Priestly Smith,[2] in a series of 200 cases, secured binocular vision of some kind in 28.5 per cent. of the cases by the use of non-operative treatment alone, a very close agreement in results obtained in the cases reported by me.

W. Lang and James Barrett[3] reported a series of 102 cases in which 36.3 per cent. were cured by means of glasses alone, but they counted the cases which had five degrees and less of squint as cures, while I have not done so. I have counted no case as a cure which did not have parallelism, the angle alpha being taken into consideration. Judging from all of the statistics that I have been able to look up, I would say 30 per cent. of all cases of squint may be cured by non-operative treatment alone. Such a result certainly justifies our persistent and careful trial of this method of treatment in every case before resorting to operation.

As valuable as the non-operative treatment is before operative measures are undertaken it is just as valuable,

2. Trans. Ophth. Soc. Unit. King., vol. xviii, 1898, pp. 17-47.
3. Ophth. Hospt. Reports (London), 1889.

or more so even, in completing a cure after operation. He who operates on a squint and does not follow it up with after-treatment and close observation will fail to make a cure in many cases. While, if the cases are followed up with the non-operative treatment, the cure is often completed.

The younger the patient and the earlier the non-operative treatment is begun the better the results. This point has been shown by all observers who have reported cases, and is a well-established fact.

Of the 34 cases which came to operation 29 cases were convergent and 5 divergent. Hypermetropia was present in 31 cases, 3 of which had divergence; myopia was present in 3 cases, one of which had convergence.

Twenty-six of the cases, or 76.47 per cent., secured parallelism, 11 of which latter cases, or 32.35 per cent., secured single binocular vision, and 2, or 5.88 per cent., binocular vision. Five cases, or 14.70 per cent., had over-effect, and 3 cases, or 8.82 per cent., had under-effect. After two operations on two cases of over-effect, and on one case of under-effect two of these cases secured parallelism, making the percentage as follows: parallelism, 82.36 per cent.; over-effect, 11.76 per cent.; under-effect, 5.88 per cent.

The remaining cases of over-effect and under-effect are still under observation, and if it becomes necessary will be operated on a second time. In cases of over-effect the second operation is performed upon the opposite muscles to those which were first cut, and in the same way, that is, they are stretched and then cut. In one of the two cases of over-effect that was operated on a second time, advancement of the muscles first cut was performed, but it did not relieve the over-effect; while the other case that had the opposing muscles stretched and cut secured parallelism.

These 34 cases here reported, taken in connection with the 36 cases operated upon by Panas' method and reported by Dr. Roosa eighteen months ago, make 70 cases in all that we have observed sufficiently to report upon. Twelve of the cases that Dr. Roosa reported in 1899 and 1900 have been seen in the last month (May), and the others have been seen now and then since his report. In his first report there was one case of over-effect. The

over-effect in this case has diminished until only about five degrees of divergence remains, though ten degrees was present originally. In one case a convergence has resulted, while in two other cases divergence has resulted —one of ten degrees and the other of twenty-five degrees, but this latter case was a complicated one, that is, there was a central opacity of the cornea in the squinting eye. In other words, in two cases the tendency was to divergence, while in two other cases it was towards convergence. Divergence, therefore, after Panas' operation is no more to be feared than convergence, judging by these cases operated upon eighteen months to two years ago.

The results on the whole 70 cases at the present writing are as follows: parallelism, 60 cases, 85.7 per cent.; over-effect, 7 cases, 10 per cent.; under-effect, 3 cases, 4.2 per cent.

[I may say, since compiling the tables of cases for this paper, I have operated on 6 other cases in the clinic, all of which secured parallelism and one single binocular vision. If we add these cases to the 70 here reported the number of cures would be about 87 per cent.]

In these cases it must be remembered that two operations were performed on only 3 cases, the desired effect being obtained by one operation together with non-operative treatment. And it is this very feature of the operation, its effectiveness on one trial, which makes it superior to other operations. To show the value of this operation as to ultimate results it is only necessary to compare it with results obtained by the old methods of simple tenotomies, advancements, etc.

In 1886, Roosa reported a series of 100 cases of convergent strabismus, which he had operated upon, with results obtained, together with the review of the subject of squint. In this paper he said he had been able, after careful search, to find tables comprising a scant 300 cases. Of the 100 cases he operated on parallelism was secured in 79 cases, or just 79 per cent.; convergence remained in 16 per cent.; divergence in 4 per cent., and upward squint in 1 per cent. That is to say, 21 per cent. were failures although he operated on some of the cases two or three times, and stated that in some cases, not included in his tables, he had operated four and five

times on a single case. His results in these 100 cases are a fair average as compared with the results obtained by other operators who used the same method. The results obtained by the same operator and his pupils by Panas' method are considerably better, and are secured in the great majority of cases, as observed earlier in this paper, by one operation, which is certainly a great gain over the method of simple tenotomies, where two, three and as high as five operations are sometimes necessary to complete a cure. Furthermore, the main objections against Panas' operation, over-effect, has not been borne out by the statistics in the 70 cases reported by us and the 250 cases reported by Panas. Panas reports failure in only about 5 per cent. of his cases.

By way of explanation of the greater percentage of failures in the cases reported by Roosa and myself, as compared with the cases reported by Panas, I may say three of our cases were operated upon while the patients' eyes were under the influence of a mydriatic. In each one of these three cases over-effect resulted, due, we believe, to the effect of the mydriatic. Under no circumstances should Panas' operation be performed while the eyes of the patient are under the effect of a mydriatic. Because, immediately following Panas' operation, as a rule, we have a temporary over-effect, and the mydriatic increases it and makes it permanent. It is easy enough to instill a mydriatic if the effect of the operation is not great enough, but it is impossible to get rid of the effect of the mydriatic, for some days at least, when once in. We therefore give word of warning to those who intend to operate after Panas' method not to do so while the patient's eyes are paralyzed with a mydriatic.

In a very few cases a second operation is called for, but with this second operation I believe the percentage of cures (parallelism) will easily be brought up to 95 per cent. in all cases.

*Cases Worthy of Special Mention.*—Cases Nos. 1 and 8 are remarkable in showing triplopia immediately after operation; the former case being of interest also by reason of the vision in the amblyopic eye increasing from 20/200 to 20/30.

Each of these cases, aged respectively 23 and 25 years, had excessive convergent squint in the left eye from

youth, the latter case having but little amblyopia in the squinting eye, while the former had a very decided amblyopia. In each case immediately following the operation there was horizontal triplopia for the near point, and for the distance also for bright objects, as a candle-flame. The second case, No. 8, in the first table, would at times have triplopia, then diplopia and then single binocular vision—all within a few minutes' time. When triplopia was present the image from the right eye was between the two images from the left, and was the brightest of the three, while the extreme right hand image was the faintest of the three. When diplopia was present (in this instance the images from the maculæ were fused, forming one image, while the faint image to the right was from the new-formed macula in the left eye) left image was very bright while the right was very weak.

It required the most favorable surroundings to bring out the triplopia, as a bright light in a dark room. Looking at a white door-knob at twenty feet immediately afterward, he had single binocular vision as shown by prism test.

With the Kroll pictures, the trap and the mouse, for instance (the trap being on the left side of the picture in front of the squinting eye), he saw two traps and the mouse between them. After two days triplopia could not be brought out, and single binocular vision existed from this time on until eight months later when the patient was last seen.

The first case, No. 1, was exactly like the one just recited, except the image from the false macula was weaker. Furthermore, on account of his amblyopia it required a much longer time for him to obtain single binocular vision, taking five weeks to establish it. At first he saw single at five feet and then single binocular vision extended to within one foot of the eyes and as far away as ten feet after a few weeks. Beyond ten feet he had homonymous diplopia, while inside of one foot he had cross diplopia. Five months after the operation the range of single binocular vision was from eight inches to fifteen feet, and he was able with the Kroll pictures to put the mouse in the trap, the flower in the pot, the frog in the pool, etc., but not to fuse the

homologous objects of the Kroll pictures, as the two girls or two horses, so as to form one girl or one horse. His vision in the amblyopic eye had increased to 20/50, at this time. One month later the vision in the bad eye increased to 20/40, and single binocular vision existed for all distances beyond six inches. He was able also now to fuse the homologous objects of the Kroll pictures.

A third case somewhat similar to the two cases here reported is one from the hospital clinic where paradoxical diplopia followed operation. E. S., aged 11 years, divergent strabismus, 30 degrees, constant most of the time in the right eye, though occasionally the left eye squinted; duration 10 years.

R. V. 20/70; 20/20 w. —1.50 D.

L. V. 20/40; 20/20 w. —1.00 D.

The treatment consisted in wearing glasses and having Panas' operation performed. Immediately after the operation there was a divergence of ten degrees, but a homonymous diplopia of six degrees. Ten months after operation the patient had single binocular vision both with and without glasses.

The three cases just cited and the two to follow form other links in the chain of positive evidence in favor of amblyopia ex anopsia, but before commenting on them I will cite the two cases in hand of marked amblyopia which were greatly improved by treatment.

A. S. (Case 9 in Table 2), aged 6 years, convergence 25 degrees, constant in the left eye, duration one year, true fixation, R. V. 20/30; L. V. 10/200. Under atropin:

R. V. 20/100; 20/20— w. +3.00 D.

L. V. 10/200; 20/200 w. +3.50 D.

These glasses were ordered and the exclusion pad to be worn one hour three times a day over the right eye; also atropin was instilled twice a day into the eyes for a month at a time with intermissions of a month. After three months the amount of the squint was reduced to fifteen degrees, but could not be further improved with three more months of treatment, making six months of all of non-operative treatment. Panas' operation was now performed. On the following day the eyes were parallel, and on the second day after operation single binoc-

ular vision was present for the near point. The exclusion pad was ordered to be worn one hour three times a day on the right eye; three months later single binocular vision existed for all distances with vision 20/20 in each eye with glasses, + 3 D. each. Adduction 13 degrees, abduction 6 degrees, sursumduction, right and left, 3 degrees.

Another case in point, No. 16, Table 2: Ada D., age 38, high myopia, convergence 60 degrees right eye, with false fixation, 10 degrees convergence left eye; duration twelve years. R. V. 3/200 not improved; L. V. 4/200; 20/50 w. —12 D. ⌒ —1.50 C. 180°.

The ophthalmoscope showed 12 diopters of myopia in each eye, with normal fundi, except for small scleral ring at the disk in each eye. Ordered glasses —10 D. R.; and —10 D. ⌒ —1.50 C. 180 L. Two weeks later Panas' operation was performed; five days later the eyes were parallel. The patient was ordered to wear her glasses all the time and to wear the exclusion pad on the left eye twice a day for an hour. Thirteen months later the patient had single binocular vision with glasses on, and the vision had increased in the amblyopic eye from 3/200 to 20/50, the same as in the good eye.

The two cases of triplopia and the one case of paradoxical diplopia show that a new perceptive center can be formed in the eye by use, while the last case shows that the center of vision, after it is much reduced, can be improved by use. And Roosa, Risley and others have reported cases where the vision was good before squinting and became reduced after squinting, showing that the vision may be reduced by non-use.

I am as firmly convinced that the non-use of an eye may cause weak vision or amblyopia as the non-use of a man's arm causes weak muscles in the arm. Physiologically one is as easily understood as the other. A quotation from Brudenell Carter is pertinent here: "Vision," he says, "like every other nerve function, must be cultivated for the attainment of a high degree of excellence. The visual power of London children is not cultivated by their environment. They see the other side of the street in which they live, and the carts and omnibuses of the thoroughfares. They scarcely ever have the visual attention directed strongly to any ob-

ject which it is difficult to see or which subtends a visual angle approaching the limits of this ability; and hence the seeing function is never exerted to anything like what should be the extent of its powers."

Three of the patients reported by me in this paper have complained that the sight in the good eye has been made worse by tying the eye up, it taking at least one-half hour to one hour to recover the normal vision after the patch is removed.

Case No. 12, in Table No. 2, is unique because of the great size of angle alpha, which was 20 degrees in each eye, measured very carefully with the perimeter, time and again.

W. H., aged 16, left eye has always turned outward, mother and two sisters have divergent squint when they become tired. The amount of divergence is 25 degrees, exclusive of the angle alpha, but it looks much greater on account of the very large positive angle alpha.

R. V. 20/15; 20/15 + w. +.50 D.

L. V. 20/50; 20/30 + w. +.50 D. ⊃ +.50 C. 75°.

Panas' operation was performed at once because the glasses had a tendency to make the squint worse. The immediate effect of operation was ten degrees of convergence; nine days later the eyes were parallel with single binocular vision for all distances. His wide angle alpha, however, gave him the appearance of having divergent squint, the so-called incongruous squint of Donders, or apparent squint of other writers. Six months later the patient had single binocular vision by all tests, with and without glasses, and was entirely comfortable, although he had not worn his glasses for two months.

So far as my knowledge goes a 20-degree angle alpha is the largest on record. Cases of as high as twelve degrees have been reported, but I knew of none larger until meeting with this one.

Another case worthy of report is the following: J. O. C., aged 12, convergence of the right eye since an infant, constant; amount 45 degrees, true fixation.

R. V. 20/50; 20/30 w. +1.50 D. ⊃ +1.50 C. 90°.

L. V. 20/50; 20/20 w. +2.75 D. ⊃ +.75 C. 90°.

These glasses were ordered together with atropin and the exclusion pad. Five weeks later the eyes were

parallel for the distance with five degrees of convergence for the near point. After three months' treatment single binocular vision was present, which is still maintained. This case is remarkable because of the amount of the squint—45 degrees, the age of the patient before treatment was begun—12 years—the duration, twelve years, and for the result.

CONCLUSIONS.

1. That it is desirable that we have a uniform or standard set of tests for the accurate measurements of strabismus.

2. A better understanding of the physiological action of the ocular muscles and of physiology in general, than at present obtains, should be had by those treating and operating on strabismus cases.

3. The amblyopia present in most cases of convergent strabismus is functional and acquired, and not congenital except in rare cases.

4. The non-operative treatment of strabismus—atropin, the exclusion pad, and, in patients old enough, glasses, the stereoscope and bar-reading—should be begun as soon as the squinting is observed; for, it is in the early cases that this form of treatment is capable of doing so much good. By means of it, if the case is taken in time, false fixation and suppression of the image in the squinting eye are prevented, fusion of the images encouraged, and form-perception, that is, true binocular single vision often maintained. Even where one or more of these functions have been lost persistent effort in the non-operative method of treatment frequently restores them.

5. About 30 per cent. of all cases of strabismus may be cured by non-operative treatment alone.

6. Just as soon as the non-operative method of treatment ceases to improve the condition of the squint, it is time to operate. Delay in operating after this is not only useless but harmful, because the habit of suppressing the image in the squinting eye becomes fixed and the amblyopia worse.

7. After the eyes have been operated on, the use of the stereoscope, bar-reading, the pad, glasses, etc., are of the utmost use in completing the cure.

8. Panas' method of operating for strabismus by

stretching the muscles before cutting them is to be recommended as safe in execution, quick in results and efficient. It should never be performed while the patients' eyes are under the influence of a mydriatic.