of the world; having been associated with Dr. John A. Long in the old Marine Hospital at San Francisco on his return from the Philippines, when he showed us for the first time we had amebiasis as a common disease in California, and taught us that many other parasites heretofore ignored were with us; and having acted as medical supervisor through many years for various steamship companies, the writer feels he can state with some authority that Doctor Reed in his paper has been very modest in calling our attention to the great value of a school of tropical medicine in California.

There is nothing one can add to his paper in the form of discussion, as he has covered the ground so thoroughly. I would emphasize, however, that organized medicine throughout our land should make it one of its first duties to help carry out all the recommendations and suggestions Doctor Reed has so carefully placed before us. The medical men in our country are directly affected by the importation of so-called tropical diseases.

The support for such a school should be more easily forthcoming from "Big Business" because it can be so readily shown to save many dollars of cost on account of quarantine and fumigations, and the loss of time of valued employees through sickness. We all know how much easier it has always been to acquire public moneys for the protection of pigs than for the protection of human babies.

OCULAR MUSCLE OPERATIONS*

By Joseph L. McCool, M. D.
San Francisco

Discussion *by Roderic O'Connor, M. D., San Francisco; Hans Barkan, M. D., San Francisco.*

THE establishment of a correct diagnosis of any pathological condition before applying treatment is so fundamentally sound in principle that it seems rather superfluous to present a paper dealing with such a subject. Nevertheless, it is a fact that the success of an operation on the ocular muscles depends upon accurate knowledge of all factors which enter into the development of the muscular anomaly for which the operation is to be performed. It is only within comparatively recent years that ophthalmologists have made critical studies of underlying causes of motor anomalies before applying treatment. Even today many convergence and divergence anomalies are treated as if they were the result of abnormalities of the lateral muscle when, as a matter of fact, not a few are the result of dysfunction of the vertical ones.

Before discussing in detail the various types of heterophoria and squint that lend themselves to surgical correction, the anatomy of the ocular muscles and the physiology of ocular movements will be briefly considered. This is, of course, familiar ground, and only a few slides to emphasize certain points will be shown.

BROAD SCOPE OF MUSCLE OPERATIONS

All types of motor anomalies are amenable to surgical interference. In order that the subject may be approached in a systematic way it should be divided into two sections: (1) squint, functional and paralytic; (2) heterophoria.

DIAGNOSIS OF FUNCTIONAL AND PARALYTIC SQUINTS

The differential diagnosis between functional and paralytic squints ordinarily is not very difficult to make. In the first place, the history is often not only suggestive, but in the vast majority of cases is conclusive. This is particularly true in young children.

If the squint is present from birth it is nearly always paralytic, whereas functional squint first makes its appearance when the child begins to regard objects at close range. If the mother is a close observer, her testimony may be relied upon, but it must not be forgotten that in children whose fusion faculty is weak the establishment of binocular single vision may be delayed until the child is nearly a year old. At this time the eyes will be straight and will remain so until something occurs to disrupt the fusion faculty, usually some disease of childhood or a fall. An unobserving mother will, having failed to recognize this interlude, testify that the child's eyes have always been crossed.

Diplopia, the most valuable and constant of all the symptoms of ocular palsy in the adult is of no value in young children, as it is a subjective symptom and, even if recognized by the child, its character could not be determined by the surgeon. Its presence, however, may be inferred by the way the child holds its head. This symptom will be discussed later.

Limitation of movement is much easier to study in an adult than in a child, and yet, even with very young children one can quickly elicit this symptom by utilizing the light projection test. By having the child regard a small electric light in the primary position and then making quick movement of the light laterally or in the oblique positions, the child's eyes will instinctively follow the light and any lagging of one of the eyes may be detected. The difference between the primary and secondary deviation may be determined roughly if the child is at all tractable, although it is sometimes difficult to get a youngster to concentrate on fixation long enough to give the information desired. They are more likely to look at the examiner than at the light.

Enough has been said to show that, ordinarily, it is not difficult to diagnose a paralytic squint even in young children. However, it is not nearly so easy to differentiate purely functional squint from that caused by a slight paresis of one of the muscles, and, because the treatment is radically different, it is a very important differentiation to make.

In functional squint in young children it is rare indeed to find any limitation in temporal rotations, for it is only in those cases which have lasted a long time that contractures and tissue changes take place in the external and internal recti muscles. If, on the other hand, one finds some temporal limitation of movement in one or

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both eyes in a child obviously too young for tissue changes to have taken place, a diagnosis of paresis is justifiable. Certainly it should be given careful consideration in building up our diagnosis.

Of much more frequent occurrence is that type of convergent squint due to congenital paresis of one of the vertical muscles. In this group the superior recti are the muscles at fault in the majority of cases. Either one or both may be affected with or without ptosis. Usually the picture is that of paresis of one superior rectus muscle with secondary spasm of the opposite inferior oblique muscle, an example of primary and secondary deviation. I have seen one case in which the deviation was caused by paresis of the inferior rectus muscle with spasm of the opposite superior oblique muscle. This latter type is rare. A diagnosis of functional convergent squint is made frequently when the cause of the squint lies in a paretic superior rectus muscle. Of course it is very difficult to say how many cases are the result of this anomaly, but I am sure the actual number is greater than is usually believed.

While the recognition of the two forms of convergent squint—alternating and monocular—is not difficult, it is well to remember that the results obtained from the surgical treatment of alternating squint are sometimes disappointing. In alternating squint there is a congenital antipathy to binocular single vision; one may obtain simultaneous macular perception, but no fusion with the amblyoscope. In monocular squint the fusion sense is present though only superficially developed in a large proportion of cases. In alternating squint the best that we can hope for from operation is a cosmetic cure; in monocular squint, if the fusion sense is present and demonstrable with the amblyoscope before operation, binocular single vision may be achieved by surgical means plus amblyoscopic training.

Of the various deviations in which binocular single vision is present, but maintained only by the expenditure of excessive nerve impulses, the vertical ones are responsible for the greatest discomfort to the patient. It is true that esophoria and exophoria can and do cause acute distress to their possessors, but, in my experience, the discomfort is not to be compared to that caused by hyperphoria. The person who has exophoria, though uncomfortable when regarding objects at a distance, suffers more when using his eyes at the occupational distance; anyone suffering from esophoria may be comparatively comfortable when reading or sewing, but may suffer when using his eyes for distant vision. For the hyperphoric person there is no point from infinity to extreme convergence at which the maintenance of binocular single vision is not accompanied by distress of varying degrees. This is directly dependent upon the stability of his nervous system.

In the above, in a general way, the muscular anomalies which, under certain circumstances, call for surgical treatment have been enumerated. With the possible exception of a complete paralysis of an ocular muscle the presence of which can be detected by one symptom, limitation of movement, it is necessary to study the patient by applying a number of diagnostic tests.

DIAGNOSTIC PROCEDURES

The importance of a careful history has already been mentioned. This cannot be overestimated in making a diagnosis. A comparative study of the vision of the two eyes in any case of squint will enable us to determine whether it is alternating or monocular. Any disparity in the corrected vision of the eyes, in the absence of any opacity in the media or of fundus disease, points to monocular squint. In alternating squint corrected visions in the two eyes is equal, or nearly so.

In every case of squint an effort should be made to determine, by means of the amblyoscope, the state of the fusion faculty. If simultaneous macular perception only is present before operation, a cosmetic result may be expected. True fusion with or without amplitude offers the prospect of a functional as well as a cosmetic cure. If the child has depth perception before operation, the prognosis is still more favorable. The deviation in degrees of arc should be measured by any of the familiar methods.

Of the various tests for the diagnosis of heterophoria and squint, there are none which can compare in simplicity and effectiveness to the screen and its subjective complement, the parallax test. Because of their reliability in diagnosis the writer will describe them as he uses them, with particular reference to the information to be gained by studying the behavior of the eyes in the six cardinal directions of the gaze.

The patient is directed to look at a spot of light slightly below the level of his eyes twenty feet away and a blinder is passed quickly to and fro from one eye to the other.

If there is orthophoria neither eye will deviate when covered and each, consequently, will remain steady when the screen is removed. If, however, there is a squint or heterophoria of more than a degree or two, each eye when covered will deviate and when uncovered will turn back into fixing position. Thus, if there is either an esophoria or convergent squint, each eye in turn will deviate in, or toward the nose, when covered and will swing out again when uncovered.

Squint and Heterophoria.—Having thus ascertained that a deviation is present, we next differentiate between a squint and heterophoria. To determine this we make the patient look fixedly at the test object with both eyes open, and then alternately cover and uncover one eye, say the right, leaving the other uncovered all the time (method of binocular uncovering). By thus covering the right eye we compel that left to fix, if it is not already doing so, and we allow the right eye to deviate if it has any tendency to do so or if it is not already deviating.

In this case three conditions may obtain:

1. There may be heterophoria. In this event the left eye which if fixing already will continue

to fix when the right eye is covered, and the latter, which was fixing before being covered, will deviate. Then when the cover is taken off again the right eye will swing back into place and the left eye will remain fixing, *i. e.,* both on applying and removing the screen but one eye will move, and that the one which is being covered.

2. There may be squint of the right eye. In this case the left eye, which was fixing before the right was covered, will continue to fix, and the right eye, which was deviating before it was covered, will remain deviating. Then when the right eye is uncovered again, the left eye will still remain fixing (because it is the eye that habitually fixes) and the right will still remain deviating (because it is the eye that habitually deviates). That is, both on covering and uncovering, neither eye moves, provided the cover is put over the squinting eye.

3. There may be a squint of the left eye. If so, the left eye, which was deviating before the right was covered, will now have to move into place in order to fix. As it moves into place, the right eye, which is behind the screen, will move out of place. Then when the screen is removed the right eye, which has thus become deviated, will move back into the fixing position, since it is the right eye which ordinarily fixes when both eyes are open, and the left eye will move out of its fixing position and back to its ordinary position of deviation. That is, both on covering and uncovering, both eyes move, provided that in the case of a squint the screen is put before the fixing eye.

If repeated applications of the test show that sometimes the right eye squints, sometimes the left, we are dealing with alternating strabismus.

As we are passing the card from eye to eye in making the screen test, we ask the patient whether or not the object at which he is looking seems to move. If it does, it means that he is actually seeing double, only, instead of seeing the two images simultaneously, he sees one after the other. Thus, if, on uncovering the right eye, the object seems to move to the right, it means that the right eye image is to the right of the left eye image, *i. e.,* the patient has homonymous diplopia (esophoria). If under the same conditions the object seems to move to the left, he has crossed diplopia (exophoria). If it moves down he has a right hyperphoria; if up, a left hyperphoria.

While these tests are accurate and reliable when applied in the primary position, their value is greatly enhanced when the eyes are turned in the four oblique and two lateral positions, for it is in these positions that a deviation, the result of paresis of one or more muscles, will reveal itself.

However, before making the screen test and parallax test in the outlying field, it is better to investigate the field of binocular single vision with a red glass before one eye. If diplopia develops, it usually points to the offending muscle or muscles. Not infrequently, in spite of the interposition of the red glass, the fusion sense is so strong that there is no diplopia. In these cases the screen and parallax test may be used with the result that fusion is coaxed into abeyance and a characteristic diplopia develops.

Occasionally, if the patient is told to gaze steadily at the point of light held in the field under examination for ten or fifteen seconds, the eye with the weaker muscle will gradually lag enough to isolate the offending muscle.

One of the best means for revealing latent deviation is the monocular patch. In this country Marlow and O'Connor are the chief advocates of this method of diagnosis. Duane disagreed with them, believing that "prolonged occlusion did not reproduce the actual motor relations as they exist in the given case, but rather tended to make the eyes revert to their infantile state in which, not being controlled by coördinate impulses, they exhibit a varying imbalance."

I believe this objection to the method is more fancied than real, for it is hard for me to believe that the use of the monocular patch for one week on an individual who has enjoyed binocular single vision for all but a year of his life would so far disrupt his fusion sense as to permit his eyes to wander as they did in infancy. Whatever one may think of its value in revealing latent errors in motor balance, there can be no question as to its usefulness in differentiating muscular ametropia from accommodative asthenopia. The information gained from a study of the field of monocular fixation is helpful but by no means conclusive. If three readings taken on the lateral, vertical and oblique positions show a consistent limitation in one field, the muscle whose action is predominant in that field may be considered to be deficient in power.

A study of the action of the two eyes working together is of far more practical importance. A small electric light is best suited for the purpose. The patient is asked to follow the light with both eyes open when it is carried in the six cardinal directions of the gaze. If one eye lags we suspect the muscles into whose field of action we are carrying the light. While doing this it is well to observe the action, not only of the supposedly paretic eye, but also of its fellow. This test should be made with both eyes open, followed by a test with one or the other eye screened from the light but not from our view. Take, for example, suspected palsy of the right external rectus muscle. When the eyes are carried to the right the right eye lags while the left follows the light. During this maneuver, in all probability the left eye will fix. If, however, we screen the left eye and make the right eye fix while carrying the light into the field of action of the right external rectus, the left eye will be seen to deviate markedly to the right as the result of secondary deviation caused by overaction of the left internal rectus.

Even though this paper deals with the surgical treatment of muscular deviations, it must not be assumed that nonsurgical treatment has been neg-

lected. The refraction, under the most profound cycloplegia, should be carefully estimated in all individuals up to the age of forty-five. However, patients forty years old and over should have tonometric measurements made before using a cycloplegic and, if the readings are around the upper limit of normal, they should be kept under observation until the pupils have returned to normal. Without entering into a discussion of the refractive side of this subject, I should say that wearing glasses which correct a low compound hypermetropic astigmatism with the rule will have but little influence in correcting a deviation. The same cannot be said of higher errors, especially if the astigmatism is oblique and myopic. Myopic astigmatism and anisometropia are, however, important factors, and a correction for the latter should be worn long enough to remove any possible doubt in the mind of the surgeon that the deviation was caused by the ametropia. Fortunately for our patients the number of those who still cling to the belief that if the refraction is corrected the deviation will take care if itself, is gradually, though none the less surely, diminishing and I hope will finally disappear.

SURGICAL TREATMENT OF MUSCULAR ANOMALIES

In the surgical treatment of muscular anomalies we have four types to consider:

1. Complete paralysis of one or more muscles in which the rotational power of the muscle is completely abolished.

2. Paresis of one or more of the muscles in which the rotational power is diminished but not abolished.

3. Functional squint in which the deviation is caused by faulty coördination and not by any inherent weaknesses in the muscles themselves except in a very limited number due to structural and insertional anomalies.

4. Heterophoria caused by paresis of one or more muscles, faulty coördination, or structural anomalies and insertional anomalies.

When the deviation develops as the result of a complete paralysis of one of the ocular muscles, the lesion is usually in the nerve supplying it. In a small percentage of cases, especially in those following injury, the muscle itself may be injured; or it may be congenitally deformed or absent. Surgery, therefore, must be directed toward other muscles whose function has not been impaired. If the recti muscles are at fault, portions of the adjacent recti muscles may be transplanted and attached to the insertion of the paralytic muscles with very satisfactory results. If the superior oblique muscles are palsied, two procedures are available, both of which are planned to compensate for the elevation, adduction, and extorsion of the eye caused by palsy. A recession of the opposite inferior rectus muscle may be done, or the superior rectus muscle in the paralyzed eye may be transplanted back and to the temporal side of its original insertion.

So long as a muscle is not completely paralyzed, but retains a measure of its rotational power, it may be attached directly. In low deviations a shortening of the offending muscle may be all that is needed. If, however, the deviation is fairly high this procedure may have to be augmented by a recession of its opponent.

In functional convergent squint in which it has become evident that conservative treatment will not cure, the surgeon should not hesitate to advise operation even as young as four years of age. The operation of choice is, of course, a shortening of one or both external recti without any interference with the internal recti. Where the convergent squint is of long duration and is considerable in amount, the surgeon is justified in supplementing the shortening with a recession of one of the internal recti; later the opposite internal rectus may be receded if conditions warrant it.

In divergent squint, shortening of the internal rectus muscle with complete tenotomy of the external rectus on the deviating eye is the operation of choice. If the effect is insufficient, a shortening of the opposite internal rectus may be done, supplemented by a more complete tenotomy of the external rectus later if it is indicated.

In hypertropia, if one eye is amblyopic the superior rectus of this eye should be shortened, supplemented, if necessary, with a recession of the inferior rectus. Here, however, a cosmetic result only is sought. If the vision is equal, or nearly so, in both eyes, and if by vertical prisms we are able to establish fusion, a recession of the opposite superior rectus should be performed if the full correction of the deviation is not attained by shortening of the superior rectus of the hypotropic eye. Where there is any possibility of securing binocular single vision it is better not to disturb the inferior rectus if it is possible to avoid it.

Heterophoria offers ample opportunity for the application of surgical measures for its alleviation. Many patients, sufferers all their lives, have been made comfortable by carefully planned and well-executed operations of the offending muscle or muscles. We must not lose sight of the fact, however, that, with the exception of those cases of heterophoria caused by paresis and the few cases dependent upon structural and insertional defects, the vast majority are caused by faults in the coördinate movements of the two eyes.

Hyperphoria.—Before considering any operations for hyperphoria it is well to remember that the spurious forms must be ruled out. I mean by this that not a few cases are the result of a refractive error. Obviously this must be corrected and observed for at least six months. We must also rule out the results of diseases of the central nervous system and the toxemias, syphilis of the brain and cord, neoplasms, lethargic encephalitis, diphtheria, influenza, diabetes, and so forth, before considering operation.

The remaining varieties of this imbalance, namely, the intrinsic and paretic, are the ones to which we should direct our attention.

If the deviation does not exceed four prism diopters and the patient is made comfortable with the vertical prisms in his correction, I believe an operation should not be performed, with this exception: if it can be shown, and this is easy to do, that the asthenopia is muscular rather than ametropic and the individual is anxious to dispense with glasses, I believe we are justified in recommending a shortening of one of the vertical recti muscles for the correction of the defect. If the deviation be more than four prism diopters, wearing prisms is sometimes annoying to the patient, and, because we can offer them a reasonable prospect of relief, we should urge operation.

The operation of choice is a shortening of one or more of the vertical rectimuscles. It is worthy of special mention that a tenotomy should never be done for hyperphoria.

Esophoria.—The patient with esophoria is extremely difficult to handle either surgically or otherwise, for back of the anomaly lies a very unstable nervous system which is usually the cause of it. On the other hand, unless the deviation itself is properly handled it tends to aggravate the underlying condition. In other words, a vicious circle is established which is often very baffling. The use of prisms in the correction is seldom beneficial.

In divergence insufficiency a shortening of one or both external recti is indicated, but if in addition to this there is a convergence excess a moderate recession of one, or even both, internal recti may be needed. Theoretically recession of one or both internal rectus muscles should be the operation of choice, but in practice it is safer to shorten the external recti and rely upon other measures to reduce the sensitivity of the nervous system.

Exophoria.—If there is a pure divergence excess with ample convergence, especially in the low amount, I always use prisms supplemented by orthoptic training and proper hygienic measures. If the exophoria for distance is under ten degrees, and particularly if prisms in the correcting glass fail to give relief, a tenotomy of one, or even both, external rectus muscles may be sufficient. It is, of course, understood that the lateral expansions of the tendon are left intact. If, in addition, there is a definite convergence insufficiency, a bilateral shortening of the internal recti is indicated. However, it must not be forgotten that of all the different types of muscular anomalies it is this one which responds best to orthoptic training, and this should always be given most thorough and conscientious attention before operation is considered.

It is, of course, obvious that no hard and fast rules can be applied in treating these anomalies, and very careful studies should be made of each individual before operation is recommended. Furthermore, all nonoperative measures should be given a fair trial. If they fail, however, operation should be advised and urged, for with the surgical means at our disposal any competent surgeon should be able to make these people comfortable.

SUMMARY

1. A knowledge of the anatomy and physiology of the neuromuscular apparatus is essential before operating on the ocular muscles for the correction of heterophoria or squint.

2. In paralytic squint portions of the adjacent muscles must be used to effect rotation in the fields of action of the palsied muscle; no operation on the affected muscle will change the position of the eye. If the muscle is only paretic, much can be gained by shortening this muscle. If, however, the deviation is fairly high, this procedure may have to be augmented by a recession of its opponent.

3. In functional convergent squint in children under six years of age it is better to shorten one or both external rectus muscles, reserving control tenotomy or recession of the interni for subsequent adjustment of the visual axes. Where the convergent squint is of long duration and considerable in amount, the surgeon is justified in supplementing the shortening with a recession of one of the internal recti; later the opposite internal rectus may be receded if conditions warrant it.

4. In divergent squint shortening of the internal rectus muscle with complete tenotomy of the external rectus in the deviating eye is the operation of choice. If the effect is insufficient, a shortening of the opposite internal rectus muscle may be done, supplemented by a complete tenotomy of the external rectus later if it is indicated.

5. In hyperphoria if the deviation is four diopters or less, prisms will usually suffice. If greater in amount, shortening of the weaker muscle will usually suffice. A tenotomy should never be done for hyperphoria.

6. In esophoria, theoretically, recession of one or both internal rectus muscles should be the operation of choice, but in practice it is safer to shorten the external recti and rely upon other measures to reduce the sensitivity of the nervous system.

7. If the exophoria for distance is under ten degrees, and particularly if prisms in the correcting glass fail to give relief, a tenotomy of one or even both external rectus muscles may be sufficient. It is, of course, understood that the lateral expansions of the tendon are left intact. If the exophoria for distance is more than ten degrees, shortening of one or both internal rectus muscles is indicated. This treatment is particularly also indicated in convergence insufficiency when there is no exophoria for distance.

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DISCUSSION

RODERIC O'CONNOR, M. D. (450 Sutter Street, San Francisco).—Doctor McCool and I are medical classmates and we have kept in fairly frequent contact since I came to California in 1914, after my resignation from the Army Medical Corps. He adopted my "cinch" or "hitch" tendon-shortening method soon after I announced it in 1912 and has never given

it up. I wish to take this opportunity to thank him for his strong argument in its favor before the 1929 meeting of the American Academy. The Barkan brothers are recent converts, and are apparently very enthusiastic.

Doctor McCool and I have had frequent talks on our pet subject, and so far have found only one thing upon which we disagree, namely, tendon recession. I do not like it because a complete tenotomy is done and scleral sutures are used, neither of which procedures appeals to me as safe surgery. It takes very little set-back of a tendon to destroy the power of convergence which should be preserved in *all cases* of *esophoria* and in those of esotropia where we hope to secure binocular vision.

When more than one tendon shortening is required I prefer a definite two-stage tenotomy. This consists of a central tenotomy, leaving uncut marginal bands about two millimeters wide. These are strong enough to take the full muscle action. If more effect is desired, a measured amount of the central section may be excised, in which event the whole procedure becomes a two-stage resection. After a month, during which time the cut portion reattaches to the sclera slightly back of the original insertion, the marginal bands are cut without touching the central portion. The central cut is usually made at the time its opponent is shortened because it can cause no harm. Frequently the marginal cuts are not needed. The advantages of this scheme, *which I believe is original,* are that at no time is control of the globe lost, such as might happen after a tenotomy anchored by scleral sutures, and we have avoided the use of such sutures. This fits in with my whole idea of muscle surgery which is to do all the work on tendon tissue, carefully avoiding the globe.

This scheme was explained to Doctor McCool several years ago when he came down from Portland to see, by assisting in a number of operations, just how I did my shortening. Apparently I did not convert him to its value.

This two-stage operation works out very nicely in cases of exophoria with strong convergence. Recently I operated on a little girl of nine who had twenty-two degrees exophoria which was reduced to four degrees by this method applied to both eyes. She permitted it to be done under local anesthetic.

As to vertical deviations. For many years this has been my pet hobby, as I feel that only by my method can most of these be handled surgically with safety. The following cases emphasize Doctor McCool's argument.

At the 1923 American Medical Association meeting I presented a little girl in whom a marked left esotropia was changed to an esophoria by shortening the right superior rectus as the *only* operation.

Another patient had twenty-five degrees of exophoria with a noncomitant left hyperphoria twenty-three degrees due to a definite right superior rectus paresis, Shortening this tendon caused complete disappearance of both deviations as shown by maddox tests.

At this place I wish to make a point in the diagnosis which was not emphasized in the paper. When such patients fix the light in downward rotation the eyes usually come parallel, as shown by the light reflections centering in each pupil. On upward rotation the deviating eye takes its lateral position and is higher than the other.

A complicating feature of these cases is the frequency with which the eye with the paretic superior rectus is used for fixation, the eye with the normal muscle squinting. When it is suggested that operation be done on what the parents or patient think is the good eye, the "ruction is on." It took me three years to persuade the father of the little girl mentioned above, and he is a medical man.

A third patient upon whom operative procedures have just been finished had as his first complaint "terrific headaches." His tests showed esophoria nine degrees before monocular occlusion, which caused instant stoppage of the pain. His condition finally settled to hyperphoria three degrees, and to lateral orthophoria. Prism three degrees, divided equally, was ordered, with no return of headaches. A refractive error of cylinder one diopter in each eye was ignored at this trial of prisms, proving that the sole cause of his symptoms was the hyperphoria. After wearing the prisms, only three degrees of the original esophoria returned. Consequently I do not agree with Doctor McCool on the point of lenses during vertical deviations, and must repeat that the true state of affairs can only be found by monocular occlusion.

When should squints be operated?

For many years I have been doing these operations as close to the third birthday as possible, with some as early as the middle of the third year, provided, of course, that corrective lenses have failed to straighten the eyes. The eyes *must be parallel—a mere reduction in the degree of squint being worthless from the standpoint of binocular vision.* This point I explain carefully to the parents. In this connection I wish to make the positive statement that I have never seen eyes come parallel with correction, unless they did so as soon as it was put on or, at least, as soon as the effect of the atropin is off. Therefore, if one is certain of the accuracy of his correction, there is no need to wait for years or to make many examinations and changes in prescriptions.

I am now of the opinion that the interests of the vast majority would be best served by operating as soon as the squint appears and with one year as the lower limit. To my viewpoint this is the only way by which a child can be given a chance to learn binocular vision in a normal manner. By this practice I believe we could prevent the development of the habit spasms and relaxations that appear in accordance with Sherrington's law. My shortening can do no harm and, of course, tenotomies would be out of the question in such small children. I am aware that some unnecessary operations would be done but, as Deaver used to say about immediate appendix operations, "The thing that is best for the greatest number is the thing to do."

As to tendon transplantation. I have worked out two variations of transplantation for abducens palsy. One is the use of the pair of muscles complete instead of the outer halves. I have done this operation five times, but in two of the patients marked vertical deviations were produced which makes me prefer the second method. This is a transplantation of the *inner* three-fourths of the vertical recti, *under* the uncut outer fourth, to the externus. By this procedure all of the tendon is external to the median plane of the eye, thus increasing the chance of securing outward rotation, and there is no tension against the anchoring suture such as occurs when the inner portion is left in place. I recently operated, for Dr. Otto Barkan, both eyes of a congenital bilateral abducens palsy by this method, with results satisfactory even to the patient.

The possibility of operating for triple effects was not mentioned in the paper. This is to be considered when a worthwhile amount of cyclophoria is present. For instance, if an operable case of esophoria shows plus cyclophoria and hyperphoria in one eye, a shortening of the lower margin of its externus tends to give a triple correction. Similarly in a case of exophoria with plus cyclophoria and hyperphoria in one eye, a tenotomy of its externus, *except its lower margin,* tends to secure a triple effect. Many times I have been successful in these cases.

I have said nothing about the tests and methods of establishing a diagnosis because the paper left nothing to add. I am sorry that the comments on monocular occlusion were so lukewarm in its favor, because its use in about twenty-five hundred people makes me certain of its value as I am of the need for cycloplegics in refraction work. In fact, I could get

along much better without the latter, if forced to give up one of the two.

The lesson to be learned from this paper is that muscles must not be operated by rule of thumb methods such as, "advance the externus and cut the internus." Operators *must learn* that "rough stuff" is entirely out of place in a *delicate surgical procedure that aims to parallel the visual axes.* Muscle surgery is just as much a specialty in itself as plastic or neurologic.

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HANS BARKAN, M. D. (490 Post Street, San Francisco).—Doctor McCool's excellent summary of methods of diagnosis of the 'phorias and 'tropias needs no comment. It is logical, definite and to the point, and the beginner in ophthalmology could do no better than to systematically follow the routine he outlines.

We are also advocates of early operation, provided that a reasonably quick, satisfactory result is not obtained by glasses, fusion exercises, etc. Since adopting Doctor O'Connor's operative method we find that operation can be performed at early ages. No harm can be done and an opportunity for fusion training is obtained early in life. I would caution, however, to remember that the swing of the pendulum frequently goes too far in one direction and not to forget the many good results obtained in previous years by occasional carefully performed tenotomies and by systematic occlusion, glass-wearing, and exercises over longer periods. We have repeatedly seen third degree fusion established in children with no binocular vision before operation, when operated upon and trained afterward, even at the ages of seven to nine years, so that to obtain this desirable result it is not *always* necessary to operate at a very early age, although many times desirable, seldom meeting with any difficulties. The O'Connor operation, as such, we adopted as the most perfect mechanical means of straightening eyes at any age. With such perfect mechanical means the results have been highly satisfactory.

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DOCTOR MCCOOL (Closing).—In reply to Doctor O'Connor's criticism of the recession operation, I should like to say that if the sutures are placed so that they do not pierce the sclera, and only include the superficial fibers, the operation is perfectly safe and effective. One need not fear a loss in converging power unless the tendon insertion is set back too far. It is easier to do and, I think, quite as effective to use three mattress sutures of fine silk and insert them in the thick scleral tissue around the old stump of the tendon.

I do not think that convergence is weakened to any greater extent than it would be by the two-stage operation, and the advantage of one operation over two is not to be lightly considered.

The point brought out by Doctor O'Connor about the difficulty of persuading the patient that at times the eye that deviates is the wrong one to operate upon, is important. Of course we know that this is due to the well-known fact that patients prefer to fix with the paretic eye to make diplopia less disturbing.

The citation of one case of hyperphoria made comfortable by vertical prisms does not disprove my statement that there are certain cases of hyperphoria dependent upon ametropia and that these will disappear when the refraction is properly corrected.

With reference to the age at which operation should be performed, I think that Doctor O'Connor and I are in accord, with this exception: I do not believe that if the eyes do not become straight as soon as the glasses are worn and the atropin wears off that they will not become straight without operation. I believe glasses should be worn at least a year before we can say with certainty that they will not cure the squint.

THE RELATION OF PATHOLOGY TO LEGAL MEDICINE*

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IT is my purpose to contrast briefly the status of legal medicine in Europe and America; to show the close relationship to pathology and to propose a scheme for the organization of an active department of legal medicine in the medical schools of the country, using as far as possible the existing conditions.

I take my definition of legal medicine from Draper's textbook: "Legal medicine is that department of medicine which teaches the application of every branch of medical knowledge to the needs of the law, whether civil or criminal."

THE CURRICULUM AND LEGAL MEDICINE

Having this definition in mind, it is obvious that every physician, whether he be a general practitioner, a specialist, or a laboratory worker, will have use for legal medicine in his work. Thus it follows that every medical student must be allowed the opportunity to obtain knowledge in the subjects treated upon in legal medicine. If this is true, where shall the student obtain such knowledge? There are those who say that each department in the medical school should consider and teach legal medicine. Let the professor of chemistry teach the detection of poisons, the identification of blood stains. Let the anatomist discuss the identification of human bones, the age and sex and proportions of the body, the effects of exposure and decomposition. Let the surgeon warn against malpractice in treating fractures and dislocations and fully describe knife and gunshot wounds, and automobile injuries. Have the obstetrician discuss the duration of pregnancy, the diagnosis of rape, abortion and delivery. Allow the pathologist to direct attention to the technique of medico-legal necropsies and describe trauma. It has been urged that these subjects be introduced in their proper place in each course, thus covering the field.

The refutation of the above proposals is that in present-day teaching the work is left undone. An instructor in a medical, as in other schools, teaches what interests him. If he dislikes a topic, it is treated briefly or not at all. Then, too, there are many subjects that are not properly placed in any course. Are these to be omitted even if they are as important as medical evidence in court, the identification of bodies, the rights of a physician and patient, and the liability of both?

Another group of critics who oppose a separate department of legal medicine in the curriculum will say that if a physician is well trained and knows his anatomy, chemistry, surgery and obstetrics, if he is honest and tells the truth, that he need not fear attending any court. This is true as far as general knowledge goes, but medical questions assume a very different aspect and

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