an access of 8 or 9 D. over the normal refraction (the normal being from 41 to 43 D.), with a still further increase of 2.5 D. in the opposing meridian. With $-9 \text{ C} - 2.5 \text{ 10}^\circ$ vision advanced to $\frac{5}{24}$. The form of the cornea examined by Placido's disk showed no irregular astigmatism. The patient was most positive in his statement that previous to the inflammation his distant vision was good, and that while living on the plains he could distinguish small objects at a distance better than most of his companions. Assuming then, as is warranted, that the eye was emmetropic to begin with, we have here a corneal myopia of 9 D., and an astigmatism of 2.5 D. according to the rule, which we can probably refer to pressure exercised on the cornea when it was in an inflamed and softened condition. The kind of astigmatism would seem to carry out our idea that astigmatism according to the rule is caused by lid pressure.

That the changes from inflammation in the cornea, however, are not always those causing an increase of curvature is shown by the following case:

H. M., aged 16, suffers from the interstitial keratitis of inherited syphilis. She was under observation for a number of years, and was almost totally blind from the corneal combined with uveal inflammation. The cornea cleared up to a degree after a time, and in the left there was some useful vision remaining; the right was practically useless. Measurements of the left cornea gave the following: $15^\circ 35 \text{ D. } 120^\circ \times 2\frac{1}{4} \text{ D.}$ The form of the cornea was only moderately irregular, but there was a lessening of curvature amounting to at least 6 D. in its general refracting power, with a further diminution of 2.25 D. in one of its meridians. A $+ 2.5 \text{ axis } 90^\circ$ increased vision from counting fingers at 3 meters to $\frac{5}{60}$. The $+ 6 \text{ D.}$ did not give an additional improvement.

A few words now in regard to the practical use of the instrument: It is true that it is not an apparatus that requires much time or practice to learn to manipulate properly, and yet certain conditions for its most successful operation are essential. In this country I do not think artificial illumination is at all necessary when a window can be used, which looks out to the open sky; but the relative positions of the instrument and the patient should be such that the patient's body does not form any obstruction to the light falling on the white bands in any position of the arc. This particular position, however, can be readily found by experimenting. It may not be without interest or value to those beginning the use of the instrument to know of the method I have found most satisfactory in recording ophthalmometric measurements. It is the shortest and simplest possible. I first find the meridian of least refraction as shown by the touching of

the two hands at their bases, I note the direction of this meridian, and then turn the arc until the bases of the bands are even again when the crossing of the one over the other is greatest. This amount of crossing I read on the corneal reflex, and note the meridian in which it occurs. The position of the right movable band on the arc gives the refraction of the weakest meridian in dioptries. This gives us all the necessary data, and I record it as follows, for example: $L. 45^\circ 23, 135^\circ \times 2$; this means that the meridian at 45° has a refraction of 43 D. (since 20 D. has to be added from the position of the white band on the left-hand side of the arc to the position of the band on the right-hand side, in order to get the total refraction of that meridian in dioptries). This, as you see, gives us, at a glance, the refraction in the weakest meridian, the direction of that meridian and the difference expressed in dioptries, between that and the refraction in the strongest meridian shown in the number of steps crossed, which is, of course, at right angles to it.

THE FULL CORRECTION OF AMETROPIA.

Read in the Section of Ophthalmology, at the Forty-second Annual Meeting of the American Medical Association, held at Washington, D. C., May, 1891.

BY EDWARD JACKSON, A.M., M.D.,

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There is fairly general agreement that theoretically the emmetropic eye is the ideal eye; that it approaches its work under the most favorable conditions, that its possessor is to be congratulated, and that when an ametropic eye suffers from strain, one of the most important things that can be done for it—no matter what the kind of ametropia, no matter what its grade—is to give it the optical aids that will make the conditions under which it works more nearly approach those of the emmetropic eye. But in practice, I am aware that very many of you will not agree to follow the logical train to its legitimate sequence, that the best optical aid that you can furnish the ametropic eye is that which will most exactly conform its conditions of labor to those of the emmetropic eye; that is, the full correction of its ametropia.

The position that if the emmetropic eye works under the best possible conditions, the conditions that most nearly approach these are the best that can be secured for the ametropic eye, is so strong, that the burden of proof must be held to lie entirely on those who contest it. Let us examine some of the things that are urged against the full correction of ametropia.

It must be admitted, in the first place, that all lenses cause, when first used, certain disturbances in the relations of the visual acts. The spherical lens disturbs the relations between ac-

commodation and convergence, and differences between the correcting lenses of the two eyes necessitate a revision of the act of binocular fusion. On these accounts, for every pair of glasses put on there must be a longer or shorter period of adaptation. Of this period I can only say that other things, *including the strength of the glasses*, being equal, I am convinced that this period is on the whole apt to be less prolonged and less annoying when the correction for ametropia is a complete one, than when it is partial.

Taking up the objections to a full correction, in the various forms of ametropia, of astigmatism I shall say nothing, for the objections to its full correction are not generally allowed to influence practice, and have to do solely with the period of adaptation.

HYPEROPIA.

In hyperopia it is urged that patients will not or cannot see clearly at a distance if given the correction for total hyperopia. Probably the majority of ophthalmic surgeons believe this to be the case, and each could adduce cases innumerable to support his opinion. But let us see if there be not some more rational explanation of these cases, than the one of supposing that the hyperopic eye is subject to a species of inveterate normal "spasm" of the ciliary muscle, from which other eyes are quite exempt. I have never seen a case of such spasm that did not yield, allowing perfect distant vision with the correction for total H., within two months of the constant wearing of the lenses. I have seen but few that did not yield in two weeks, it is a quite exceptional case that does not yield in a few days, and in the great majority of eyes there is perfect distant vision from the start, if the glasses are commenced before the eye has entirely recovered from the influence of the mydriatic. I have repeatedly investigated cases of supposed inveterate ciliary spasm, and in each instance the supposition has been found to have no substantial basis.

But certain things must be borne in mind. First, that the glass that gives the best correction at 4 or 6 metres is not the correcting glass for the total H., but is an over-correction of $\frac{1}{4}$ or $\frac{1}{6}$ D. I know of no treatise on this subject that takes this into account. It seems like a very small matter. It is often convenient to call rays parallel that come from such a distance; but, strictly speaking, they are not parallel, and the glass that focusses them perfectly on the retina will not perfectly focus parallel rays. This $\frac{1}{4}$ or $\frac{1}{6}$ D. of inaccuracy introduced by the assumption that such rays are parallel, is just the inaccuracy that will make the entire difference between success and failure in the effort to correct the total hyperopia. Patients given a 0.25 D. over-correction, will not become accustomed to it and

see clearly at a distance in any length of time. This inaccuracy must be avoided if you are going to correct the total H. That is, instead of giving the glass that gives the best vision at 4 metres, we must order a lens $\frac{1}{4}$ D. weaker. Another thing to be borne in mind is the aberration of the eye. As I pointed out four years ago (see Trans. American Ophthal. Society, 1888), in the great majority of eyes, the refraction at the margin of the pupil differs from that of the centre. So the lens accepted with the dilated pupil, may be too strong or too weak when the pupil has contracted again.

If with the dilated pupil too weak a lens has been selected, it may be accepted even for really parallel rays, when the pupil is contracted, and this is the only way that we can ever account for the acceptance of the 6 metre correction by an eye that has perfect distant vision without any lens. But if the lens chosen for the dilated pupil is too strong for that portion of the pupil that remains in use after the contraction of the sphincter of the iris, even if the $\frac{1}{4}$ D. for the 4 or 6 metres divergence be deducted from the lens selected under the mydriatic, the remainder will still, for distant vision, be an over-correction, and no eye previously accustomed to perfect distant vision will ever accept it.

Another way in which this notion of the non-acceptance of a full correction has come about, is through the ordering, after an examination without a mydriatic, of a supposed exact correction, or supposed under-correction, which is in reality an over-correction. It comes about in this way. We get the impression from the books, and from our own experience, that latent hyperopia is present in most young eyes. It is found quite generally that young eyes will not, as the influence of a mydriatic goes off, or immediately after it has gone off, accept the convex correction that they did when under the mydriatic.

But my case records have proved conclusively to me that even where this was the case, the latency of the H. is not a fixed condition, but has often appeared after the use of the mydriatic. For instance, an eye showing H. 1.75 D. at first examination, and choosing the + 1.75 D. lens under duboisia, has, a week after the discontinuance of the duboisia, accepted nothing stronger than + 1.25 sph. Now, if I had not made the pre-mydriatic test, I would have supposed this eye brought to me 0.50 D. of its H. latent. And if, acting on this supposition, I had prescribed for the next case of the kind, without using a mydriatic, the strongest lens he could see clearly with, at 4 metres, I might have supposed myself safely inside of a margin of latent H. when no latent H. existed, and actually given an over-correction that would render all things slightly indistinct beyond 20 feet.

My experience shows that young hyperopes

very frequently come to us with none of their H. latent; but you can never certainly know if this be true in any given case, without the use of a mydriatic. I have repeatedly had to remove over-correcting convex lenses that had been ordered without the use of a mydriatic, and have found weak convex cylinders, ordered without mydriasis, where corresponding concaves were needed; the surgeon having been led by what usually happens as to low astigmatism, into prescribing the wrong lenses in the case with which he had to deal at the time.

But if it is admitted that the full convex correction would be accepted in all cases, if steadily worn for a few weeks or days, it will be urged that the great majority of patients will not submit to the inconvenience of those few days or weeks. The difficulty here is psychological. It does exist, I admit, but is serious in a comparatively very few cases.

Our patients usually come to us ready to submit to a good deal, if only we gain and keep their confidence that the ultimate result will be relief. They come ready to submit to the inconveniences of loss of time from business, while they wait day after day in our offices, to submit to the payment of our fees, often to the annoyance of a mydriatic, and the great majority of them will submit to this inconvenience of temporary indistinctness of distant vision, if it is not accompanied by a loss of confidence in the wisdom of their counselor.

In ordering a correction for the total H. a portion of which is latent, it makes all the difference between success and failure, whether we fully warn the patient of the indistinctness of distant vision he is likely to experience, and the length of time it is likely to continue, exaggerating this rather than minifying it, and explain the cause of it; or whether we leave the patient to discover the dimness and its duration for himself. In the one case he will remember our explanations as evidence that we foresaw the difficulty, that we knew what we were about. In the other case, he will be liable to regard our explanations as apologies designed to cover up our mistakes. Then this explanation of the annoyance, which may be illustrated by placing glasses before the eyes that produce it, will enable one to judge whether the particular patient will submit.

It may be said that the deductions I have urged on account of the divergence of rays from points 4 or 6 metres distant, and on account of the aberration of the eye, amount in effect to about the same thing as the practice of giving the correction for the manifest H., or of throwing off a certain fixed proportion of the total correction. But they do not; any more than that amounted to exact justice when the ruler cut off the head of one of his subjects on the first day

of each month, not because that particular subject had done anything worthy of the death penalty, but because probably, during the month, some such crime would be committed within his dominion.

MYOPIA.

The unwillingness of surgeons to order the full correction for myopic eyes, notwithstanding the fact that such a correction would give the best distant vision, is probably based wholly on fear of causing increase in the myopia by strain of the accommodation. I know of no sufficient clinical evidence to support the supposition. My experience indicates that the constant wearing of the full correction lenses, no matter what their strength, with careful attention to other points of ocular hygiene, checks promptly and permanently the advance of myopia in the majority of cases. I have recently examined the eyes of a lady who, as a school-girl, suffering from rapid increase of myopia, was given the full correction of the high compound myopic astigmatism over fifteen years ago, and it practically corrects her error of refraction to-day, and her ocular health is now excellent. Experience has led me year by year to order the full correction of higher degrees of myopia, with greater confidence, in any case that habitually has or can get fair binocular vision, such glasses usually being worn by young people for near as well as distant vision.

Let us see on what considerations the contrary practice is founded. Apparently on theoretical considerations which I believe to be incorrect. Iwanoff stated that he found essential differences between the ciliary muscle of the hyperopic and that of the myopic eye. Later investigators have failed to confirm it, and it is probably incorrect. Then many works state that in myopes, because it is less used, the power of accommodation is less than in hyperopes of the same age. My measurements of the power of accommodation indicate no considerable difference. Of course, myopes, putting on strong concave lenses, have great difficulty in near seeing, at first. But this is due simply to the disarrangement of the accustomed relation of accommodation to convergence, is a phenomenon of the period of adaptation, and careful determination of the range of accommodation for each eye singly shows that it is not deficient in accommodative power. Sometimes, indeed, it is essential to break the transition to the full correction, by partial correction; but this is merely a step toward the end, the constant wearing of the full correction.

This statement is not intended to apply with full force to cases of myopia that have given up binocular vision, or where the vision is so poor from other causes that distinct focussing of rays on the retina cannot be fully appreciated, but it does apply strictly to the great mass of cases of myopia.

Another thing that has misled some very careful students, is the fear of increased congestion of the vascular coat from increased functional activity of the ciliary muscle, increasing the intraocular tension.

The belief in increase of the intraocular tension by accommodation is founded on two things, namely: certain experiments on the eyes of lower animals, and the increase of pulsation in the retinal veins on active accommodation. Of the experimental evidence it may be said, that it is quite contradictory; much the better of it, as it appears to me, seeming to show that there is no increase of intraocular tension in the globe with accommodation. But the conditions of the experiment are so different from those of normal human accommodation, that it has very little force one way or the other.

As to the increased pulsation that occurs in pulsating veins under strong accommodation, we must remember that we cannot increase the tension of the ciliary muscle without increasing that of the internal rectus, and if actual convergence does not occur, it is only because the tension of the external rectus is also increased, and in either case the result is necessary increase in the pressure on the globe from without; to which it is far more rational to ascribe the increased pulsation than to a supposititious influence of the accommodation.

I am not inclined to underrate the importance of hyperæmia in producing distension of the globe, but it is pathological hyperæmia, not physiological. I recognize fully the influence of eye-strain in the production of myopia, but it is eye *strain*, not eye *use*, that does it. We must discriminate more sharply between use and abuse. The normal performance of function is just as necessary to health, as the abnormal excess of demand is dangerous to it. And without adducing additional evidence which is at hand, I rest the claim that, for the myopic as for the hyperopic eye, the most favorable conditions for labor that can be imposed on it are, in general, those under which the emmetropic eye works, most nearly brought about by the wearing of the full correction.

Therefore, in my practice and in my teaching, I have laid it down as a cardinal rule to give the full correction for ametropia—a rule to which exceptions are to be made, but only for special, clearly marked and important indications.

DISCUSSION.

DR. G. C. SAVAGE said: There are cases of ametropia in which a full correction cannot be made. For instance, in a case of astigmatism with one eye according to the rule and the other contrary to the rule, if the meridians are one vertical and the other horizontal, full correction can be given; but if the meridians are oblique it

will give rise to confusion, due to oblique direction of the eyes. In myopia in one eye and hyperopia in the other, there is no strain so long as looking through the optical centres of the lenses; but in looking down, for instance, near him, the deviation of the eyes from the optical centres produces confused prismatic action, on account of the contrary prismatic effect of the lenses when oblique. Such lenses can only be tolerated by decentering them. Again, in hyperopia in both or myopia in both eyes, but differing in degree, the same irregular prismatic displacement occurs when not looking through the optical centres, and the muscles are likewise put on a strain.

DR. GEO. M. GOULD: A word as to full correction. It is commonly said by the advocates of full correction that we are to aim to put the eye in an emmetropic condition; that this is the ideal condition we seek to bring about. I deny the major premises *in toto*. The wherefore is correct if the whereas is allowed. I cannot allow it. And for the following reasons:

1. The history of the pair of eyes we are prescribing for is often, and generally, one of abnormal use, of abuse long continued; the eye, from its history, is in an abnormal condition, and cannot be proceeded with as if it were a normally and physiologically reacting organ.

2. Long abnormalism of deficiency or excess of function has begotten organic changes in the eye itself and its innervation mechanism. In hyperopia the ciliary muscle is excessively developed, in myopia it is excessively weakened, in astigmatism it is unphysiologically developed. These organic and functional changes cannot be neutralized quickly, and will continue to mar the results of all cast-iron rules for a time dependent upon the length of evolution of the defect, the peculiarities of reaction, vital forces, temperament, etc.

3. The work these eyes has to do is so far from ideal that abstract rules will not apply. Civilization brutally crushes ocular ideals as ruthlessly as many another. Sewing girls, bookkeepers, literary people, etc., who must work at near range from twelve to sixteen hours a day, cannot listen to ideals, whether ocular or psychical.

Many other reasons conspire to lead me to lend no ear to abstract rules. Sometimes I over-correct hyperopia, sometimes I aim at artificial emmetropia; usually I under-correct. The bitterest of errors, I think, is to fully correct myopia. I might do it in a farmer, but in an urban liver never. So long as one does it I believe many of his patients must finally leave him. Nearly all patients coming to me from other oculists are these examples of full correction. It is selfishly a good plan for us to encourage in others, but I believe it bad for our patients and our science. In myopia it puts the weakened ciliary muscle

to a strain that is the equivalent of an irritating hyperopia of a degree corresponding with the size of the error, the length of continuance, the reacting quality of the organism and the amount of near work to be done. In hyperopia the hypertrophied ciliary muscle will refuse inaction, or even a very partial deprivation of its accustomed work, for months, and if of long evolution, for years. In astigmatism the reaction comes very promptly, and I find that usually full correction is borne very satisfactorily, though even here exceptions occur. Instead of aiming at an ideal emmetropia, I find as a matter of fact I must aim usually at an ideal of slight myopia, varying from 0.37 D. to 1 and even 2 dioptics. In a myope this can be done at once, in a hyperope never at once, except for extreme near work, but often in the course of time, or by means of a second pair of lenses for near work, though presbyopia proper is a long way off.

DR. J. H. THOMPSON finds many cases where in anisometropia the slightest difference in glasses will not be borne. Thinks also it is dangerous to give full correction in myopia.

DR. JACKSON, closing the discussion, said: In high degrees of anisometropia it is necessary to properly decenter the glasses, and this is often unsatisfactory. It is impossible to correct where the difference is greater than 1.5 D. or 2 D. There are cases in which full correction is not practicable, owing, perhaps, to what the patient has been accustomed; but when it can be borne, full correction should always be given.

ONE HUNDRED CASES OF ASTIGMATISM CONTRARY TO THE RULE, AND THE ASSOCIATED SYMPTOMS.

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Ever since the days when Weir Mitchell called attention to the intimate connection between a variety of headaches and the existence of errors of refraction, before which time this close association had not received at the hands of neurologists extensive study, the literature of ophthalmology and neurology has been burdened with numerous communications upon this relationship, until now the investigation of a case of headache is not complete until the refraction of the eye and the balance of the ocular muscles have been carefully considered. All forms of refraction error are known to be the cause of headaches, and usually it is considered that the presence of astigmatism, either of the simple or compound type, aggravates the amount of the head-pain. It has been stated that when the astigmatism is contrary to the rule, the entire cor-

rection of the error is more absolutely necessary to bring relief, and that its uncorrected presence is more potent in producing general nervous phenomena, than when the astigmatism is according to the rule. More than this, the researches of Schoen on the influence of accommodative strain in the production of glaucoma and cataract are important additions to our knowledge of the influence of astigmatism, both of the usual and unusual varieties, upon the ultimate well being of ametropic eyes. So, also, Theobald, of Baltimore, has studied a number of examples of astigmatism contrary to the rule, and adduced evidence to show that under certain circumstances this condition of refraction may conduce to the development of glaucoma. The following cases were analyzed because they have been under observation for a sufficient length of time to determine in practically all of them the exact value of their correction, and also to have studied the associated symptoms in sufficient detail to demonstrate whether or not they were out of proportion to the character or the amount of the refraction error. In all of the cases a mydriatic was employed, except in those where the use of such a drug was contra-indicated by glaucomatous symptoms. In patients over 45 the mydriatic was homatropine; in those under 45 either atropine or hyoscyamine. Whenever it was necessary the spherical lens required by the age of the patient, was ordered for the purposes of reading and close vision. This glass is not set down in the notes. For the convenience of study they may be gathered into four groups:

1. Cases presenting themselves for treatment on account of optical reasons alone—beginning presbyopia, or dissatisfaction with convex spherical lenses. No pain and no reflex symptoms.

Case 1. Beginning Presbyopia.—M. T., a man aged 41; no headache; no asthenopia; tricky close vision. Healthy fundus, with the exception of slight absorption of the pigment epithelium of the choroid.

O. D. + .25s $\bigcirc$ + .90c axis 15 $\frac{1}{2}$. O. S. + .25s $\bigcirc$ + .75c axis 150 $\frac{1}{2}$. These lenses were entirely satisfactory.

Case 2. Unsatisfactory Reading Glasses (Convex).—F. E., a woman aged 57; no general disease; no ill health or reflex neurosis traceable to eye strain; unsatisfactory reading glasses. Fundus healthy.

O. D. + .50s $\bigcirc$ + .50c axis 15 $\frac{1}{2}$. O. S. + .50s $\bigcirc$ + .50c axis 165 $\frac{1}{2}$.

Case 3. Eye tire and Blurred Vision at Close Work.—L. K. B., a woman aged 30; perfect general health; no headache but unsatisfactory endurance with simple convex lenses. Normal fundus.

O. D. + 2.s $\bigcirc$ + .25c axis H $\frac{1}{2}$. O. S. + 2.25s $\bigcirc$ + .50c axis 165 $\frac{1}{2}$. The desired improvement resulted.