

MARLOW (F. W.)

The Errors of Refraction
in a Series of Two Thousand Eyes,

And Some of the Symptoms related thereto.

BY

F. W. MARLOW, M. D., M. R. C. S. E.,

SYRACUSE, N. Y.,

Professor of Ophthalmology in the Medical Department of
Syracuse University; Member of the American Ophthal-
mological Society and of the Ophthalmological Society
of the United Kingdom of Great Britain and Ireland;
Formerly Clinical Assistant at the Royal
London Ophthalmic Hospital, Moorfields, etc.

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THE ERRORS OF REFRACTION
IN A SERIES OF TWO THOUSAND EYES,
AND SOME OF THE SYMPTOMS RELATED THERETO.*

BY F. W. MARLOW, M. D., M. R. C. S. E.,
SYRACUSE, N. Y.,
PROFESSOR OF OPHTHALMOLOGY
IN THE MEDICAL DEPARTMENT OF SYRACUSE UNIVERSITY ;
MEMBER OF THE AMERICAN OPHTHALMOLOGICAL SOCIETY AND OF
THE OPHTHALMOLOGICAL SOCIETY OF
THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND ;
FORMERLY CLINICAL ASSISTANT AT
THE ROYAL LONDON OPHTHALMIC HOSPITAL, MOORFIELDS, ETC.

THE cases upon which the following paper is based were seen in private practice between April 22, 1893, and January 22, 1895. No selection has been made, the cases being taken as they came, with the exception of those having corneal or lenticular opacity, or disease at the fundus sufficient to interfere with the proper estimation of the refraction.

The examinations and records were made with a considerable degree of uniformity, both as regards practical methods and the working theories underlying them. When the cases were seen and recorded, there was no thought of tabulating them, and the records are consequently in some

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respects less complete than they otherwise would have been.

With very few exceptions each case was examined twice. In the great majority of cases a mydriatic was used previous to the second examination, a complete paralysis of the accommodation being produced.

Thus, hydrobromide of homatropine (in solution, gr. viii ad $\frac{5}{j}$) was used in 1,512 eyes or in 756 cases, sulphate of atropine in 148 eyes or in 74 cases, and in 20 cases the use of homatropine was followed by the prolonged use of atropine, on account of persistent spasm of the accommodation.

Beyond the very occasional occurrence of transient symptoms of atropine poisoning, nothing but the temporary inconvenience of accommodative paralysis can be set down against the use of these drugs.

The examinations were made with the ophthalmometer of Javal, followed by subjective tests with test types and lenses, with the ophthalmoscope, and in a certain number of cases the shadow test was used—the most accurate of all objective methods for the estimation of refractive errors. In the cases of a few young children the latter method had to be relied upon exclusively.

The ophthalmometer was used in almost every case. In rare cases only did the corneal astigmatism prove to be the only astigmatism present, in the vast majority there being a difference between the findings of the instrument and the total astigmatism, a difference which in one case amounted to 3 D.

The constancy with which a difference between the corneal and total astigmatism is found shows that some lenticular astigmatism is almost invariable, although usually of low degree.

I omitted to make any tabulation of the cases in this

respect, but the impression gained from my total experience with the ophthalmometer so far is that, while moderate and high degrees of astigmatism are mainly corneal, astigmatism of some degree (usually low) is present more frequently in the lens than in the cornea. In other words, the cases in which no corneal astigmatism exists are commoner than those in which there is no difference between the corneal and the total astigmatism—no lenticular astigmatism.

The principal meridians of the corneal astigmatism correspond usually with those of the total astigmatism in the higher degrees. In the lower degrees there may be, and commonly is, much difference. Indeed, in cases of corneal astigmatism of 0.25 D. or 0.5 D. *with the rule*, the principal meridians of the total are often placed near 45° and 135° , or even *against the rule*.

On the whole the instrument probably saves no time. In a minority of cases it gives a very useful indication of the direction in which to begin work. But in the majority it affords no information beyond the fact that there is a certain small amount of corneal astigmatism, which is of interest, but, as it bears no constant relation to the total astigmatism, practically valueless. In children it is less useful than in adults, on account of the greater difficulty in obtaining the necessary steady fixation.

Sex.—Three hundred and fifty-nine of the patients were males and six hundred and forty-one females, or thirty-six per cent. male and sixty-four per cent. female.

Age.—Sixty of the patients were in the first decade of life, 212 in the second, 275 in the third, 201 in the fourth, 138 in the fifth, 80 in the sixth, and 34 were above sixty years of age.

About fifty per cent. then came under observation between the ages of ten and thirty. Although this corre-

sponds with the observation of others, it is by no means a sure indication of the time of onset of the symptoms of eye-strain, for these have commonly existed for years before the patient has come under observation.

Statistics derived from hospital or dispensary reports bearing on the relative frequency of the different forms of refractive error are, I believe, extremely misleading, in the direction chiefly of making astigmatism much rarer, simple hypermetropia commoner, and simple myopia infinitely commoner than either really is. There seems reason, indeed, to doubt the existence of a simple uncomplicated myopia—*i. e.*, a myopia without astigmatism, anisometropia, or heterophoria.

The differences between hospital and private statistics depend doubtless on the different degrees of intelligence in the two classes of patients, on the greater amount of time which is expended in private practice on these cases, and on the fact that in hospital practice they are often relegated to the less experienced members of the staff and to students.

The following table presents a comparison between hospital and private statistics as to the grosser facts. The in-

	Total number of cases.	Cases of astigmatism.	Per cent. of total.	Simple hypermetropia.	Per cent. of total.	Simple myopia.	Per cent. of total.	Emmetropia.	Per cent. of total.
Mass. Char. Eye and Ear Inf., 1891 and 1893.	9,487	3,130	34·0	4,557	49·0	1,412	15	173	0·2
N. Y. Ophthal. and Aural Inst., 1890 and 1893.									
Newark Eye and Ear Inf., 1890, 1891, and 1893.									
Brooklyn <i>ditto</i> .	1,000	919	91·9	79	7·9	1	0·1	1	0·1
This series.....									

stitutions named were selected for the reason that their reports were ready at hand.

It has been assumed that the cases placed under the head of astigmatism included all varieties and degrees of astigmatism, that those under the heading of hypermetropia were cases of simple hypermetropia, and similarly with myopia.

While cases of astigmatism are nearly three times as common in private practice as in hospital statistics, simple hypermetropia is more than six times and simple myopia one hundred and fifty times commoner in the latter than in the former.

The following tables show the distribution of this series of two thousand eyes among the different forms of refraction :

Hypermetropia.

	Eyes.	Per cent. of hyper- metropia.	Per cent. of all.
Simple hypermetropia	229	16·0	11·4
Simple hypermetropic astigmatism	308	21·5	15·0
Compound hypermetropic astigmatism	891	62·5	45·0
Total hypermetropia	1,428	100·0	71·4

Myopia.

	Eyes.	Per cent. of myopia.	Per cent. of all.
Simple myopia	19	3·5	1·9
Simple myopic astigmatism	156	28·5	7·8
Compound myopic astigmatism	252	46·0	12·6
Mixed astigmatism	122	22·0	6·1
Total myopia	549	100·0	27·4
Emmetropia	23	1·2

By adding together the numbers of astigmatic eyes in the above tables we find that in 1,722 of the 1,977 hypermetropic or myopic eyes there was astigmatism in addition to hypermetropia or myopia. Astigmatism, then, was present in eighty-six per cent. of the total number, and consequently is the commonest of all errors of refraction, hypermetropia coming next with 71·4 per cent.

If we reckon by patients instead of by eyes, we find that 919 out of the 1,000, or practically ninety-two per cent., had some astigmatism in one or both eyes; about seventy-five per cent. were hypermetropic, twenty-five per cent. myopic, and only one patient, or one tenth of one per cent. of the whole number, was free from refractive error in both eyes.

Of 1,428 hypermetropic eyes, 229, or sixteen per cent., had no astigmatism (or less than 0·25 D.); whereas, of the 549 myopic eyes, only 19, or 3·5 per cent., were free from astigmatism. That is to say, that among hypermetropic eyes simple hypermetropia is four and a half times commoner than simple myopia among myopic eyes.

If we reckon again by patients instead of by eyes, the contrast between the relative frequency of simple hypermetropia and simple myopia is still more striking.

Thus, simple hypermetropia constitutes about nine per cent. of the farsighted, and simple myopia a little more than a third of one per cent. of the nearsighted; or simple hypermetropia is about twenty-five times as common among the farsighted as simple myopia among the nearsighted. While astigmatism is very frequently found in hypermetropes, its presence is all but invariable among myopes.

Now, when it is taken into consideration that the eye is almost always hypermetropic at birth and for some time afterward, and that myopia is an acquired condition or pathological process, developing in a certain number of these originally hypermetropic eyes, the fact that those in-

dividuals in whom one or both eyes are astigmatic are practically exclusively selected has great significance. It becomes evident that the subjects of simple hypermetropia have but little tendency to become myopic, and it seems highly probable that the presence of astigmatism is an important factor in the causation of myopia.

Glasses of different strength for the two eyes were required in 716 cases, or in over seventy-one per cent., and if a difference in the position of the axis is taken into consideration, the percentage of asymmetry rises still higher, for, of 452 cases, there was an unsymmetrical relation of the axes in over sixty-six per cent. Among the hypermetropes there was unequal refraction in about seventy per cent. of the cases, whereas in myopes it was present in about seventy-four per cent. Individuals whose refraction is dissimilar in the two eyes are, then, presumably somewhat more prone to become myopic. (In this paper a difference in refraction amounting to 0.25 D. is taken into account. If the higher degrees of anisometropia alone were considered, a larger proportion still would probably be found among the myopes.)

There is one other form of congenital anomaly which is found in a large number of cases of myopia—namely, a faulty condition of muscular equilibrium. Some form of heterophoria was present in 117 of the cases of myopia. An impression gained from the study of individual cases that these errors play an important part in producing myopia is scarcely borne out by the statistics as a whole, which give the percentage of heterophoria in myopes as somewhat less than that in the whole series. When, however, only those cases are taken into consideration in which the heterophoria has been thought worthy of correction, the situation changes. Thus, a correction for latent deviation was prescribed in thirty per cent. of the cases of myopia, in nine-

teen per cent. of other forms of refraction, and in twenty-two per cent. of the whole number of cases.

In other words, it was necessary to correct heterophoria in myopia in over fifty per cent. more cases than in other forms of refraction.

To summarize briefly :

In myopia we find astigmatism, anisometropia, and heterophoria more frequently than in other forms of ametropia; and, since the myopia has developed in eyes originally hypermetropic, the myopic process has evidently selected those individuals in whom astigmatism, anisometropia, and heterophoria were present, and consequently we find in cases of myopia two groups of conditions :

1. A congenital group, consisting of one or more of the three previously mentioned anomalies, and

2. An acquired group—the pathological elongation of the eyeball characteristic of the myopic eye, and the changes secondary to it.

I believe it is not far from the truth to say that the second group is the result of the first, plus, in some cases, certain defective hygienic conditions.

In the 245 cases of myopia occurring in this series there is no case in which one or more of these congenital defects is not present, and if these cases fairly typify the conditions found in myopia, and I believe they do, it means that ordinary nearsighted glasses—concave spherical lenses—of equal strength for the two eyes are practically never correct, and since this generalization has formed in my mind I have looked in vain for a case of simple uncomplicated myopia. The bearing of this upon practice is important, for experience is beginning to show that when these congenital defects are corrected the myopia ceases to progress, and that when they are uncorrected, and concave spherical glasses simply prescribed, the myopia tends to be pro-

gressive; and there is little doubt that the careful correction of these errors in children now just beginning will bear fruit in a great diminution in the percentage of the nearsighted in the next generation.

Astigmatism.—No case of astigmatism is recorded in this paper of less degree than 0.25 D. Although it is probable that an error of 0.125 D. produces in some persons annoying symptoms, its importance is not yet generally acknowledged, and consequently cases of this degree have been classed as simple hypermetropia or myopia.

In the majority of cases the astigmatism did not exceed 0.5 D.; in no case did it exceed 6 D.

The following table shows the distribution of all the astigmatic eyes into four groups according to the degree of error:

	NUMBER OF EYES.			Per cent. of all astigmatic eyes.
	Right	Left.	Total.	
Astigmatism = 0.25 D. to 0.5 D.	584	558	1,142	66 $\frac{1}{8}$
0.75 D. to 1 D.	165	152	317	18 $\frac{1}{8}$
1.25 D. to 2 D.	64	81	145	8 $\frac{1}{8}$
2.25 D. and upward.	54	64	118	7
Total.	867	855	1,722	100

The next table shows the direction of the axis:

	Eyes.	Per cent. of astigmatic eyes.
With rule.	1,196	69.5
Against rule.	464	27.0
Axis at 45° or 135°.	62	3.5
Axis oblique, <i>i. e.</i> , at least 5° from vertical or horizontal.	1,329	77.0
Axis exactly vertical or horizontal.	393	23.0

An analysis of the cases shows that the influence of the lower degrees of astigmatism in the production of astheno-

pia and allied symptoms is at least as great as (really somewhat greater than) that of the higher degrees.

The next table shows the relative frequency of some of the symptoms in the four groups of astigmatic cases :

DEGREE OF ASTIGMATISM.	Number of cases.	Headache.		Migrim.		Vertigo.		Photo- phobia.		Defective vision.	
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
0·25 to 0·5 D...	558	415	74·5	118	21	184	33	285	51·0	251	45
0·75 to 1 D....	175	117	67·0	37	21	38	21	76	43·0	87	50
1·25 to 2 D....	102	67	66·0	14	13	27	26	44	43·0	70	70
2·25 and upward	80	52	65·0	14	17	14	17	34	42·5	68	85

It will be observed that as the percentage of defective vision rises that of headache and the other symptoms falls.

External Ocular Muscles.—There was an apparently normal equilibrium in 453 cases. A latent deviation was demonstrated in 494. A manifest strabismus was present in 28, and in the remaining 25 cases no record was made.

The following table shows the distribution of the various forms of heterophoria in the different kinds of refraction :

	Total.	In myopia and mixed astigmatism.	Per cent. in myopia, etc.	In hyper- metropia (all forms).	Per cent. in hyper- metropia.
Esophoria	193	46	17	147	20
Exophoria	169	57	21	112	15
Hyperphoria	207	74	27	133	18

Owing to the fact that most of the cases of hyperphoria were complicated by the presence of a lateral deviating tendency, and consequently appear twice, the number of cases of heterophoria appears to be exaggerated in this table.

Esophoria, then, appears to be a little, and only a little, commoner in hypermetropic than in myopic individuals. Probably in a number of these cases the relaxation of the

accommodation following the correction of the refraction has been accompanied by a diminution in the degree of, or by a complete abolition of the esophoria, and even in some cases by the development or manifestation of an exophoria.

It certainly is a common experience to find some time after the full correction of hypermetropia or hypermetropic astigmatism that a latent divergence exists, whereas at the primary examinations no such deviating tendency could be demonstrated, or even a low degree of esophoria was present. These statistics mainly are derived from the primary examinations, as only a small percentage of the patients have come back for subsequent examination, and consequently represent a slightly too large percentage of esophoria in hypermetropia.

Exophoria and hyperphoria are distinctly commoner in myopes than in hypermetropes. Not, however, I believe, because myopia has any influence in producing them, but rather because, as previously suggested, their presence constitutes a predisposition to the onset of the myopic process.

In 219 cases, or in twenty-two per cent. of the whole number, a prismatic correction was prescribed.

Tenotomies were performed in ten cases.

Symptoms.—The commonest symptom, as might be expected, was an inability to use the eyes for near work for an ordinary length of time—asthenopia. This occurred in 810 out of the 1,000 cases.

The next symptom in order of frequency is headache, which was present in 755 cases, or in over seventy-five per cent. This occurs in every degree of intensity, from a slight dull aching or sense of pressure to the severest paroxysmal pain, requiring the administration of a general anæsthetic for its control. So far as intensity of pain is concerned, there is no degree which may not be the result of eye-strain.

Although in cases of headache from eye-strain the presence of asthenopic symptoms is the rule, there are many exceptions. Thus, in 113 of the 755 cases of headache, or in about fifteen per cent., no symptoms of asthenopia were present. This fact is of interest in connection with the statements made and opinions expressed by some ophthalmologists that eye-strain does not give rise to headache and the more unusual and remote functional disturbances without causing at the same time symptoms involving the eyes themselves—opinions certainly very widely at variance with the facts. So far from being the necessary accompaniment of headache, etc., the onset of local ocular symptoms often seems to be the occasion for the more remote symptoms to diminish or cease entirely. Every ophthalmologist must be familiar with cases in which the patient, the subject of headache or other functional neurosis, has experienced no difficulty in the prolonged use of the eyes until some definite period of life when asthenopic symptoms have developed, and coincidentally the headaches or other nervous symptoms have diminished or come to an end.

The next table shows the relative frequency with which the different parts of the head are the subjects of pain. Here again the numbers in the table are somewhat too large, on account of some cases appearing under more than one heading:

LOCATION.	Total number of cases.	Limited to this region.	Commencing in this region and extending to other parts.	Affecting this region secondarily.
Frontal.....	381	208	110	63
Temporal.....	158	58	50	50
Occipital.....	199	50	38	111
Orbital.....	121	43	40	38
Cervical ("back of neck")..	79	23	6	50
Vertical.....	98	49	..	49
General.....	17
Unstated.....	63

Time of Onset.—This was noted in 480 cases, and was as follows: In 216, on waking from sleep; in 29, soon after rising; in 102, during the latter part of the day; in 80, after use of the eyes, and in 53, at any time.

The statement has been made recently in more than one journal that the onset of headache on waking is characteristic of that due to intranasal pressure, in contradistinction to that arising from eye-strain. It may be true that the headache of intranasal pressure tends to commence on waking. It is certainly not true that this tendency is of any value in distinguishing it from that due to eye-strain.

It has been thought by some that the headache due to refractive error is more apt to be frontal, and that produced by external muscular error occipital in location.

It must be confessed that on account of the almost invariable commingling of the two classes of errors their relative influence in this regard is very difficult to ascertain. There is no doubt, however, that astigmatism may be the cause of occipital or cervical headache, and that heterophoria may cause frontal headache. The impression gained from the study of these and other cases is that the location of the headache is determined by some individual and undeterminable peculiarity in the patient—by idiosyncrasy—and bears no definite relation to the kind of ocular error present.

So far as it goes, however, the present series of cases shows evidence in favor of the idea that frontal headache is more associated with refractive error and occipital with external muscular error.

There is a higher percentage of simple hypermetropia and astigmatism of all kinds in the cases of frontal headache than in the occipital cases, and a decidedly higher percentage of heterophoria (all forms) in occipital than in

frontal headache. To this general statement there is this exception, that esophoria is a trifle more frequent in the frontal than in the occipital cases.

The following table gives the actual figures :

	SIMPLE HY.		ASTIGMATISM.		HETERO-PHORIA.		EXO-PHORIA.		ESO-PHORIA.		HYPER-PHORIA.	
	Cases.	Per ct.	Cases.	Per ct.	Cases.	Per ct.	Cases.	Per ct.	Cases.	Per ct.	Cases.	Per ct.
Frontal headache, 318 cases	21	6.5	301	94	159	50.0	46	15.0	61	19	52	16.0
Occipital headache, 88 cases.	3	3.5	80	91	62	70.5	22	25.5	16	18	24	26.5

Of the 755 cases the headache was accompanied by nausea or vomiting, and described as a "sick headache," in 187 cases.

The remaining symptoms which were taken into account in the tabulation of the cases are stated below in the order of frequency :

Intolerance of light in greater or less degree occurred in 488 cases, or in about forty-nine per cent.

Defective vision was complained of or admitted in 482 cases, or in forty-eight per cent.; but in the majority of cases amounted to only occasional blurring.

Vertigo, varying much in frequency and degree, was a symptom in 290 cases, or in twenty-nine per cent.

Lacrymation occurred in 280 cases, or in twenty-eight per cent.

Diplopia was complained of in 81 cases, or eight per cent.

Mental symptoms, such as depression of spirits, confusion of thought, nervousness, irritability of temper, etc., occurred in 71 cases, or in seven per cent.

Insomnia was present in 63 cases, or over six per cent.

Nausea, independent of headache, occurred as a direct result of eye-strain in 20 cases, or in two per cent.

Epilepsy, in 15 cases.

Chorea, in 5 cases.

Conjunctivitis and Meibomian tumors, in 51 cases.

Blepharitis, in 18 cases.

In conclusion, there are some symptoms the connection of which with eye-strain is not recognized until the correction of the latter has relieved or modified them. Foremost among these is an interference with general nutrition. It is a common experience to see a marked gain in flesh, coupled with improvement in general health, follow the relief of any form of eye-strain. The symptoms of nervous dyspepsia frequently disappear under similar conditions. The dependence of chronic dyspepsia, finally, upon eye-strain is, I believe, far more frequent than is commonly supposed.

It is not contended, however, that there is any direct connection between eye-strain and any of the remote or general nervous symptoms previously detailed. These symptoms are in the majority of cases not the result of reflex action; but it seems probable that the excessive expenditure of nervous energy to maintain clear and single vision, necessitated by the presence of refractive and muscular errors, results in a state of neurasthenia the symptoms of which vary with the idiosyncrasy, age, condition, mode of life, etc., of the patient. The refractive and muscular errors constitute a leak through which the reserve of nervous energy is lost. Without their correction the maintenance or recovery of good health is for many people impossible. As an example of the unusual symptoms which may result from neurasthenia thus induced, the following case is related:

In October, 1893, I examined the eyes of Mrs. L. I. F., who complained of nearsightedness, much headache, difficulty in seeing, even with her glasses, and a tendency to keep one eye closed.

She was wearing concave spherical glasses, 9·5 D. for the right eye and 10 D. for the left, prescribed for her some years previously by a well-known New York homœopathic oculist.

Examination showed in the right eye a myopia of 15 D. and astigmatism of 2·25 D. ; in the left, myopia of 10 D. and astigmatism of 2·25 D. ; a latent divergence of five or six degrees, and hyperphoria of four degrees. Glasses correcting the whole of the astigmatism and myopia and the greater part of the heterophoria gave her, after a day or two of discomfort, constant binocular single vision, which she had previously enjoyed only intermittently and imperfectly.

She recently reported to me that she has been perfectly comfortable with the glasses ever since, her headaches and ocular symptoms having ceased, and made the following statement: That for the two years preceding the time of examination she had been suffering from attacks of asthma of increasing frequency, finally occurring once in two weeks, and from a cough, which, intermittent at first, had become chronic for some months, and from loss of flesh. Since the change of glasses there has been no attack of asthma and the cough has completely ceased; she has gained flesh, and is in the enjoyment of perfect health. She attributes the change in her condition solely to the relief of eye-strain.

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EDITED BY

FRANK P. FOSTER, M.D.

THE PHYSICIAN who would keep abreast with the advances in medical science must read a *five* weekly medical journal, in which scientific facts are presented in a clear manner; one for which the articles are written by men of learning, and by those who are good and accurate observers; a journal that is stripped of every feature irrelevant to medical science, and gives evidence of being carefully and conscientiously edited; one that bears upon every page the stamp of desire to elevate the standard of the profession of medicine. Such a journal fulfills its mission—that of educator—to the highest degree, for not only does it inform its readers of all that is new in theory and practice, but, by means of its correct editing, instructs them in the very important yet much-neglected art of expressing their thoughts and ideas in a clear and correct manner. Too much stress can not be laid upon this feature, so utterly ignored by the “average” medical periodical.

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