[*Reprinted from Transactions American Ophthalmological Society, 1883.*]

THE ABSOLUTE STATIC REFRACTION OF THE EYE.

By EDWARD JACKSON, M.D.,

PHILADELPHIA.

This paper is based on the study of the refraction in 4,000 eyes, determined with complete paralysis of the accommodation obtained by the use of one of the mydriatics in all cases under fifty years of age, and in some up to the age of fifty-five. All cases presenting during the time covered, in which for any reason the refraction of the eyes was thus accurately determined, are included. In most cases the measurements were made by myself, and in all others under my immediate supervision. Of these eyes 2,031 were those of private patients, and 1,969 were of patients presenting themselves at the Dispensary of the Philadelphia Polyclinic. For the tabulation of the latter I am indebted to Dr. T. B. Schneideman, Instructor in Refraction and Ophthalmoscopy in that institution. The two sets of cases having been tabulated independently, the greatest difference they presented in the relative proportions of the different forms of ametropia was four per cent. in the proportions of hyperopia, there being 32.8 per cent. of hyperopia among the dispensary patients, and but 28.5 per cent. among the private patients. To balance this the private patients showed slightly higher percentages of simple hyperopic and mixed astigmatisms, and of emmetropia.

The proportions of the different forms of ametropia were as follows:

Compound Hyperopic Astigmatism,	1610 eyes,	or	40.2	per cent.
Hyperopia,	1225 "		30.6	"
Compound Myopic Astigmatism,	361 "		9.	"
Mixed Astigmatism,	267 "		6.7	"
Simple Hyperopic Astigmatism,	249 "		6.2	"
Myopia,	158 "		4.	"
Simple Myopic Astigmatism,	79 "		2.	"
Emmetropia,	51 "		1.3	"

Among the many statistical studies of the refraction of the eye there are but very few that deal with the relative frequency of the various forms and degrees of ametropia as they occur in practice. However, in a paper read here last year, and published in our transactions, p. 48, Dr. S. M. Burnett has given the refraction of 576 eyes, upon the study of which his paper was based. Of these, he says: "They can, in no way, be regarded as selected cases, since they are taken as they were recorded in my case-book, and represent very fairly, I think, the eyes that are brought to the oculist for examination." It is interesting to compare these statistics, (which agree substantially with the statistics of 806 astigmatic eyes given in Dr. Burnett's "Treatise on Astigmatism,") with the figures given above, thus:

	Burnett.		Jackson.	
Comp. H. Astigmatism, .	55 eyes,	or 9.5 per cent,	against 40.2	per cent.
Hyperopia, . . .	59 "	10.2 "	" 30.6	"
Comp. M. Astigmatism, .	63 "	10.8 "	" 9.	"
Mixed Astigmatism, .	8 "	1.3 "	" 6.7	"
Simple H. Astigmatism, .	96 "	16.6 "	" 6.2	"
Myopia, . . .	55 "	9.5 "	" 4.	"
Simple M. Astigmatism, .	140 "	24.3 "	" 2.	"
Emmetropia, . .	151 "	17.8 "	" 1.3	"

The disagreement shown by this comparison of statistics is very serious. Indeed, the order of relative frequency is almost reversed.

How is this to be accounted for? Of my own statistics I can only affirm my full confidence in their substantial accuracy. In every case the state of refraction was determined by the refraction ophthalmoscope, and also by test-lenses, and in a majority it was also measured by the shadow-test. Again, I do not entertain a doubt of the general carefulness and competence and high scientific fidelity of Dr. Burnett's investigations. Nor can it be that the number of eyes taken as the basis of his statistics is so small as to permit any great departure from the general average relative frequency of the different forms of ametropia. No consecutive five hundred eyes in my series shows any such variation from the standard of all. Then, too, the agreement with Dr. Burnett's other statistics precludes such an explanation. Finally, there seems to be no adequate reason

to suppose that the eyes presented for examination in Washington are in this respect radically different from those presented for examination in Philadelphia. There is but one thing that I can find to account for the difference in question, and that is that Dr. Burnett made over 89 per cent. of his determinations of refraction without the use of any mydriatic. The character of the discrepancy accords perfectly with this explanation. The relative scarcity of compound as compared to simple hyperopic astigmatism, of hyperopia as compared with emmetropia, the relative excess of myopia, and myopic astigmatism of all forms, indicate that Dr. Burnett's statistics are vitiated by the presence in the eyes tested of unrelaxed accommodation.

The frequency of the different degrees of refractive error among the 2031 eyes seen in private practice are given in the next table. The first column gives the different degrees, with intervals of 0. 25 D. up to 2 D., and above that with intervals of one diopter as far as the different refractive errors go. The second column gives the number of eyes presenting each degree of hyperopia. It includes not only simple hyperopia, but the hyperopic astigmatisms,* and the cases of mixed astigmatism in which hyperopia was predominant; in short, all cases in which the antero-posterior axis of the eye-ball was too short. In the same way the third column gives all the eyes having too long an antero-posterior axis, the myopias, myopic astigmatisms, and mixed astigmatisms with predominant myopia. The fourth column gives the different degrees of astigmatism of all kinds, the fifth the hyperopic astigmatisms, including the mixed with predominant hyperopia; and the sixth gives the myopic astigmatisms including the mixed with predominant myopia.

On the first line the number 58, opposite zero, represents not only the cases of emmetropia, but includes twenty cases of mixed astigmatism in which the hyperopic and myopic meridians, being just equally ametropic, balanced, the antero-posterior axis being really of the proper relative length. The 696 on the same line is the sum of the emmetropias, hyperopias, and myopias, that is, all eyes having less than a quarter diopter of astigmatism. It will be found that the sum of the hyperopic

* The degree of hyperopia in astigmatisms being taken as the mean of H. in the meridians of greatest refraction and least refraction.

astigmatisms and the myopic astigmatisms do not equal the sum of the fourth column, giving all the astigmatisms, by twenty, the number of mixed astigmatisms in which neither hyperopia or myopia predominated, and which, therefore, could not be included in either of the other columns. The degree of astigmatism in these cases can be ascertained from the table by comparing the figures on the same line in the fourth, fifth, and sixth columns, and noticing the discrepancies between the number in the fourth and the sum of the numbers in the fifth and sixth, wherever such discrepancies occur.

Of course, where the change is made between an interval of one-fourth diopter and an interval of a whole diopter, a noticeable break occurs in the diminution of the figures to be observed in reading down any column. It is also worth while to mention that higher degrees of myopia, and rather a larger number of the very high degrees of it, were met with in dispensary practice, than among the cases from private practice here tabulated. The hyperopias include no cases of aphakia.

The totals at the bottom of the table do not include the figures on the first line.

Degree in D.	Hyperopia.	Myopia.	Astigmatism.	H. Astig.	M. Astig.
0.	59	..	696	..	..
0.25	160	43	370	328	42
0.50	229	43	343	293	42
0.75	210	27	180	152	28
1.	252	21	92	68	21
1.25	179	18	65	51	14
1.50	111	21	58	35	22
1.75	88	13	25	16	9
2.	68	13	29	17	12
2.25 to 3.	167	36	81	40	37
to 4.	85	30	49	28	18
5.	29	19	30	17	13
6.	20	26	11	6	5
7.	7	8	1	..	1
8.	3	8	..	..	..
9.	3	4	..	..	..
10.	2	1	..	..	..
11.	1	7	1	..	1
12.	1	2	..	..	..
13.	1	4	..	..	..
14.	..	4	..	..	..
15.	..	2	..	..	..
16.	..	1	..	..	..
20.	..	3	..	..	..
23.	..	1	..	..	..
	1,616	356	1,335	1,050	265

Of course, such statistics are not to be regarded as indicating accurately the relative frequency of different states of refraction in the community at large. They doubtless underrate the frequency of emmetropia and hyperopia, and of the very low degrees of myopia, and, to a less extent, of astigmatism; causing relatively high percentages of myopia, and astigmatism above the lowest degrees. Still, making allowance for such tendencies, they probably come nearer to representing the true relative frequency of the different forms and degrees of ametropia throughout the whole community than any statistics obtained by other methods. At least, it is worth while to consider them briefly from this point of view.

First, with reference to the relative length of the antero-posterior axis: 80 per cent. of all eyes are hyperopic; one-half have hyperopia of 1.25 D., or less. The maximum of frequency extends from 0.50 to 1 D., including over 34 per cent. of all. Doubtless, this state of affairs comes down to us from uncivilized ancestors. Not that, under any circumstances, the hyperopic eye is better fitted for the service of its possessor than the emmetropic; but that, with uncivilized men, myopia was almost as serious a disability as blindness, and therefore to be certainly escaped, even if it were necessary, in most cases, to overstep the desired mean, and encounter the minor inconveniences of hyperopia. In a state of society in which a low degree of myopia is not *per se* much more dangerous than a corresponding degree of hyperopia, we can expect the tendency of evolution to gradually shift the maximum closer to the emmetropic standard. A very small part of the existing myopias may be regarded as due to such a movement, but the majority are certainly pathological.

When we consider the perfection of the developmental processes that such symmetry of refraction presupposes, it seems wonderful that more than one-third of all eyes are free from appreciable regular astigmatism, and that in less than one-third does the astigmatism amount to more than 0.5 of one diopter. It seems pretty certain that complete freedom from astigmatism is the standard toward which evolution has been directed all along.

Series of cases of hyperopia diminishing or passing over into myopia while under observation have been reported by Dr. S. D. Risley [Transactions for 1884, p. 751, and 1887, p. 520] and Dr. Wm. F. Norris [Transactions for 1886, p. 369]; and both these writers regard astigmatism as an important factor in the causation of such changes of refraction. If there be a connection between astigmatism and myopia, statistics like these should give some evidence of it. Let us examine them with reference to this point. The total number of hyperopic eyes was 1,616, and the cases of hyperopic astigmatism number 1,050. That is, 65 per cent. of all hyperopic eyes are astigmatic. Of the 356 myopic eyes, 262, or 73.6 per cent., are astigmatic. Here is a slight preponderance of astigmatism among myopic eyes.

It must be remembered, however, that the larger number of cases of astigmatism are of quite low degrees, and if there be a connection between myopia and astigmatism, we should find more definite evidence of it on studying the higher degrees of the latter. Taking now only the eyes presenting one diopter, or over, of astigmatism, we find that there were 278 among the hyperopic, and 149 among the myopic. That is, the proportion of eyes having one diopter or over of astigmatism is among the hyperopic 17.2 per cent., and among the myopic 41.8 per cent.

These figures indicate pretty clearly a connection between astigmatism and myopia. This connection may be either that astigmatism causes myopia, as Risley and Norris suppose, or that both astigmatism and myopia are effects of the same process, one of not entirely uniform distension of the globe — a not improbable explanation. In the former case, we would expect the astigmatism to be present before the myopia; in the latter we would expect them to appear or progress together. Cases of both kinds have been published. But among the published cases, as among cases of my own, unpublished, those in which a very considerable degree of astigmatism ante-dated the myopia, or tendency toward myopia, are decidedly in the majority.

With reference to the direction of the principal meridians of refraction in astigmatism, it was found that in these 2,566 astigmatic eyes, the direction of the meridian of greatest refraction —

that is, the direction of the axis of the convex cylinder, or perpendicular to the axis of the concave cylinder that would correct the astigmatism, was situated as follows:

Vertical, 38 per cent.

Twenty degeees either side of the vertical, from 70° to 110°, 32.7 per cent.

Horizontal, 7.4 per cent.

Twenty degrees either way from the horizontal, from 160° to 20°, 7.4 per cent.

Oblique, from 25° to 65°, and from 115° to 155° inclusive, 14.5 per cent.

These figures do not materially differ from those obtained by other observers. No noticeable difference was found between the number of eyes in which this meridian inclined upward and toward the median line, and the number in which it inclined upward and from the median line.

DISCUSSION.

DR. W. S. DENNETT, New York.— The cases given by Dr. Burnett were those in which he had used the instrument for examining the corneal curvature, and it would not be quite fair to compare them in some other way in which the ciliary muscle could have taken part.

DR. PETER A. CALLAN, New York.— These statistics are interesting, but we must not put too much weight on them. This reminds me of a little story in a German periodical. A horse-dealer called his son to come and ride a horse. "How shall I ride him," the son inquired, "to buy or to sell?" This covers the case. A patient comes, and we can find astigmatism or not, as we wish. I believe that very little value can be attached to statistics, for emmetropia exists only as an accident.

DR. H. KNAPP, New York—Where did you put the limit of astigmatism?

DR. EDWARD JACKSON, Philadelphia.— The limit of astigmatism was put at 0.25 D. More than one-third of the eyes fell below it. Dr. Burnett's paper was in reference to the curvature of the cornea in different kinds of ametropia. The figures which I have quoted are those of the number of cases of the different forms of ametropia. He assumes that these figures represent actual cases of myopia, hyperopia, etc., and on them bases his paper, stating that in a certain form of ametropia, the curvature was so and so.