The precise aim of this work is to correlate the corneal astigmatism found by Javal Schiotz Keratometer with the retinoscopic findings and thus find out the efficiency of this instrument as a measure of absolute astigmatic correction in Indians.

Materials and Observations.

3000 eyes of 1500 cases attending the refraction unit of the department of Ophthalmology were the subject of this study. Only those cases were selected who had astigmatic error as found by retinoscopy in one or both eyes. Every case was subjected to retinoscopy with Purvis Streak Retinoscope under full cycloplegia and mydriasis which was achieved either by Homatropine drops 1% or Atropine 1% ointment or drops (in children) and keratometery by Javal Schiotz keratometer. The cases having corneal pathology in the nature of keratoconus, corneal injuries or corneal opacities were omitted from the study. The patients who have been operated for cataract or for any corneal condition were also excluded from the study. The cases which showed the difference in axis of astigmatism as found out by both the methods were also excluded.

Table I shows the sex incidence and the distribution of cases into three categories (I) Simple astigmatism (II) compound astigmatism and (III) eyes with no astigmatism as seen with retinoscopy. The relationship between cylindrical and spherical error in cases of compound astigmatism was not worked out but the impression was that astigmatism increases with the increase of refractive error particularly hypermetropia and keratometry seemed more useful in Higher degrees of astigmatism. The cases were further divided to know unilateral or bilateral astigmatism. It shows that 9% had unilateral astigmatism. 13% had simple astigmatism and 87% has compound astigmatism. It agrees with the general assumption that cases with compound astigmatism are more in number than with simple astigmatism, and is borne out statistically from our figures. It is mostly present in both the eyes as is seen from our figures.

Table II shows that our of 3000 eyes examined 50.5% had hypermetropic astigmatism while 45% had myopic astigmatism. 4.5% had no astigmatism. It also shows the distribution of cases in various age groups. The incidence of simple astigmatism is inverrely proportional to age and the same rule applies for hipermetropic and myopic cases. The incidence of compound astigmatism rises with increase of age but same is not true of myopic cases. However, in hypermetropic cases, the trend is maintained in cases over 10 years of age. All these observations are statistically significant.

Table III shows the comparison of absolute value of astigmatism as found by retinoscopy (a) and corneal value as found by keratometry (c). It shows that

TABLE I

Showing sex incidence and incidence and type of astigmatism.

	Simple			Compound			Total			Eyes with no astigmatism.	Grand total
	U	B	T	U	B	T	U	B	T		
Males	26	172	198 112 cases	46	1322	1368 70 cases	72	1494	1566	72	1638 819 cases
Females	22	114	136 79 cases	40	1124	1164 602 cases	62	1238	1300	62	1362 681 cases
Total	48	286	394 191 cases	86	2446	2532 1309 cases	134	2732	2866	134	3000 (1500) cases

TABLE II

Showing age incidence and type of refractive error.

Age Group	Simple			Compound nd			Total			Eyes with no astigmatism.	Grand total
	H	M	T	H	M	T	H	M	T		
upto 10yrs.	26	22	48	76	40	116	102	62	164	12	176
11-20 "	76	98	174	334	544	878	410	644	1052	46	1098
21-30 "	38	32	70	310	282	592	348	314	662	33	695
31-40 "	16	6	22	282	144	426	298	150	448	31	479
41-50 "	8	4	12	194	122	316	202	126	328	6	334
above 50 "	6	2	8	146	58	204	152	60	212	6	218
TOTAL	170	164	334	1342	1190	2532	1512 (50.5%)	1354 (45%)	2866 (95.5%)	134 (4.5%)	3000

TABLE III

Showing comparison between A and C in various age groups.

Age Group	A more than C	A — C A more than O		A less than C A more than O		TOTAL
		A	O	A	O	
upto 10 years	34	8	98	4	32	176
11-20 years	174	16	...	30	728	1098
21-30 years	210	14	8	19	364	695
31-40 years	112	5	120	26	216	479
41-50 years	136	2	105	4	87	334
above 50 years	112	2	34	4	66	218
TOTAL	778	47	595	87	1493	3000
%	25.9%		21.5%		52.6%	100.0%

A = Absolute value as found by retinoscopy
C = Corneal value as found by keratometry.

21.5% bad purely corneal astigmatism because both keratometric and retinoscopic findings were equal 25.9% showed lower keratometric readings indicating that some extracorneal factors were contributing to the total value 52.6% showed higher keratometric readings indicating that some part of the absolute value was being neutralized by the extracorneal factors which may be in the lens. About 3% cases out of the last groups showed no astigmatism on retinoscopy showing that the corneal astigmatism was fully neutralised by extracorneal factors. The statistical evaluation confirms that proportion of cases with A less than C are higher then cases with A more than C or A = C

These findings were subjected to a statistical evaluation to judge whether these variations are statistically significant. These have been worked out on the basis of the following equation:

$$A = a + bC.$$

Where 'A' is the absolute value of astigmatism found by retinoscopy and 'C' is the keratometric reading for astigmatism while a and b are two constants. These were worked out for various age groups and separately for simple and compound astigmatism. These values differ in various groups thus made. Figure I shows the value of 'C'
value of 'C' varies as stated above. Considering all the age groups and type of astimgatism together the regression curve was plotted as shows in Fig. 2. The value of constants comes out to be a = 0.35 b = 0.75. These have also been worked out separately for simple and compound astigmatism. In simple astigmatism, the values are a = 0.15 and b = 0.90 and in compound stigmatism the value are a = —0.30 and b = + 1.2. These regression curves do not satisfy the statistical scrutiny for all types of cases in various age groups.

DISCUSSION

The value of corneal astigmatism in the contribution of total astigmatism has received little attention while this question seems to be of considerable importance as it form the most rational basis on which the biological significance of astigmatism can be determined. It is also common experience to find different values of objective assessment of astigmatic error as found by retinoscopy and keratometry hut no correlative study is available in Indians where different factors have been evaluated.

As already pointed out factors in astigmatism may be corneal or extracorneal (Marquez 1909). Corneal factors may include astigmatism due to anterior and posterior surface of the cornea. The former produces a physiological astigmatism

with the rule of the order of 0.5 to 0.75 D. (Pflaz 1885, and Sorenson 1944) Kronfeld and Devney (1930) suggested that value of 1 D is always pathological. The astigmatism due to the posterior surface of the cornea in inverse of the former and varies from 0.25 to 0.5 D (Tschering 1904). So the physiological limit of total corneal astigmatism is 0.25 to 0.5 D. Keratometers are calibrated in dioptres by using corrected refractive index of 1.3375 to give a close approximation of the value of total corneal astigmatism in persons with no corneal pathology. Under ideal conditions keratometric readings give an accuracy which corresponds approximately to 0.12 D of corneal refractive power.

On the basis of our observations we can divide our cases broadly in three groups.

I. — Cases in which the astigmatic error is same on retinoscopy and keratometry $(A = C)$, these probably have pure corneal astigmatism.

II. — Cases in which the astigmatic error as found by retinoscopy is more than as found by keratometry $(A \quad C)$. It seems that in these cases the astigmatism is partly corneal and partly contributed by extracorneal factors.

III. — Cases in which the astigmatic error as found by retinoscopy is less than found by keratometry $(A \quad C)$ - it means that corneal astigmatism is more than the total astigmatism. We postulate that in these cases part of the corneal astigmatism is neutralized by the extracorneal factors. Extracorneal astigmatism i.e. astigmatism apart from the factors in cornea comprises of astigmatism due to difference in curvature of the two surfaces of the lens, variations in refractive indices of lens and the vitreous and the decentring of the retinal elements apart from the pathological factors. These extracorneal factors play a major role in neutralization of the corneal astigmatism (Czellitzer 1927) as is evidenced in the group. We have subdivided this group where $A = O$ and $A \quad O$ and we believe that in the first subgroup $(A = O)$ the corneal astigmatism is totally neutralized by extracorneal factors. From the study of the last group, it is concluded that extracorneal factors neutralize the corneal astigmatism in part or in toto. We feel that amongst the extracornal factors differential lenticular sclerosis is probably the most important factor and in younger age group differential accommodation may be playing a significant role.

One of the most important pathological factors which may affect corneal astimgatism in this country is healed Trachoma where scarring affects the corneal curvature apart from giving rise to opacities and facets. The value of corneal factor is, therefore, of greater significance in Indians than is usually realised. We know already that the largest element of total astigmatism is due to the anterior surface of the cornea and as explained it is more so in a country like ours. Studying the
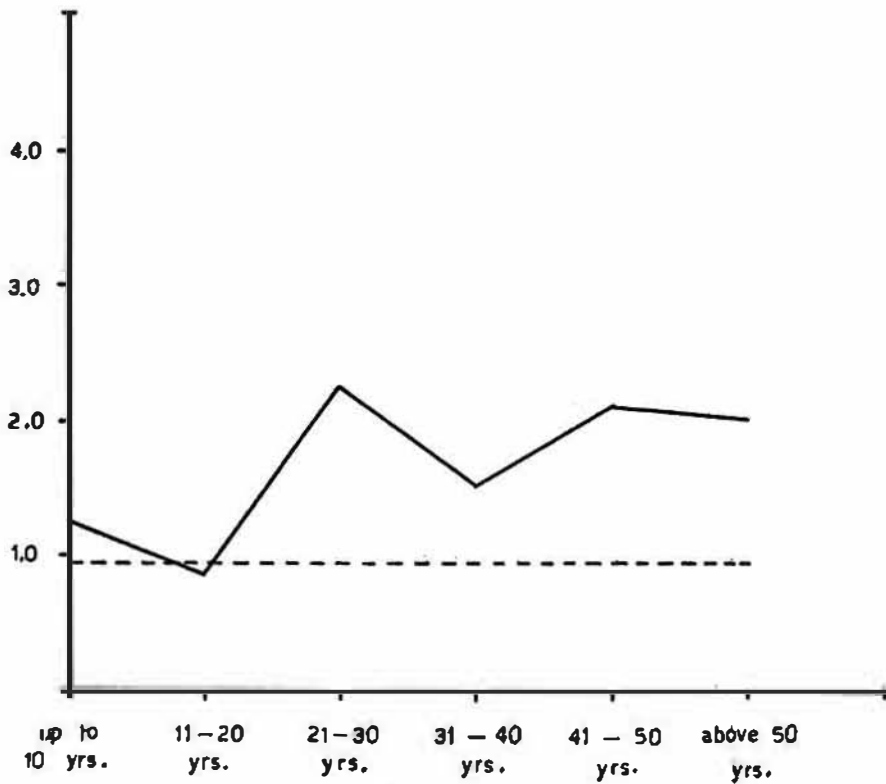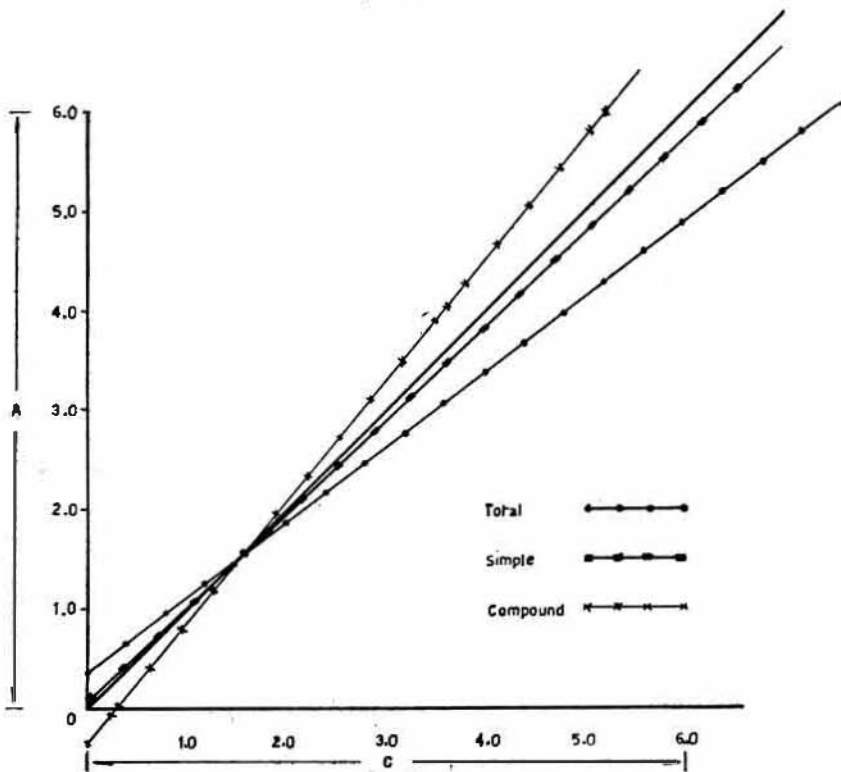
Fig. I

Fig. II

value of 'C' keeping retinoscopic findings constant in various age groups, we find that there is a rise in corneal value in age group of 21-30 years. This may be correlated with another study. (Agarwal et al 1963) in which they found that the scarring affects of trachoma are more marked in a similar age group. The neutralization of the corneal factor may be accomplished by differential accommodation or Sclerosis of the lens which may also be differential. This change is slow and is compatible with the slow process of lenticular sclerosis. Another fluctuation i:e: increase in the corneal value is seen again in the age group of 41-50 years or even above 50 years which may be accounted for by the corneal changes due to sequelae of Trachoma particularly trichiasis and entropion giving rise to irregular surface of cornea. We may conclude that astigmatism in Indians (north Indians) differs from those in Western countries because of corneal diseases particularly Trachoma.

Donders (1864) was the first to note the difference between the corneal astigmatism and the objective refractive correction. Several attempts have been made to formulate exact relationship the best known being the Javal's Rule (Javal-1881) which suggests a straight line relationship.

$$A = C \times 1.25 - 0.75$$

Neumueller (1930) commenting on it has stated that it does not hold good in every case particularly when corneal deformations and postoperative cases are taken into consideration where corneal factor is the major factor in astigmatism. It seems logical that keratometry will be more useful in such cases for objective assessment of total astigmatism. As pointed out earlier we have particularly omited these cases from our study as we felt that these cases should not be mixed up with normal cases. After elimination of these cases we have found direct relationship between the value of C & A i.e. $A = a + bc$. where the value of $a = 0.35$ and $b = 0.75$. These have also been worked out separately for simple and compound astigmatism. In simple astigmatism the valves are $a = 0.15$ $b = 0.90$ and in compound astigmatism the values are $a = -0.30$ and $b = +1.2$. It is seen from the figure 2 that 'C' works out to be larger than A meaning that as a whole corneal factor is more important than anything else in the evaluation of astigmatism in Indians. It is also interesting to note that the importance of corneal factor is still more in simple astigmatism where the values are nearly equal to total astigmatism meaning there by that simple astigmatism is mostly corneal in origin. It is all the more important as we see from the curve that the value does not differ much upto 3 D of total astigmatism. The cases of simple astigmatism above this level are rare so we can probably say that the regression curve may have some positive value in cases of simple astigmatism. In cases with compound astigmatism the curve shows that the value of 'C' is less than the absolute value

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meaning that extracorneal factors do play a positive role in the evaluation of total astigmatism. In the curve for total cases it is seen that the value of 'C' is higher than the absolute value indicating that as a whole the extracorneal factors do play some role which may be of the nature of neutralization of the corneal factors However, the regression curve does not fully satisfy the statistical scrutiny for all types of cases in various age groups and we feel that no single formula can be evolved for all age groups and types of astigmatism.

SUMMARY

1. Astigmatic error in 3000 eyes have been investigated by retinoscopy and keratometry.

2. Astigmatism in Indians is influenced by corneal disease e.g. Trachoma.

3. On the basis of our observations, we have divided astigmatism into three categories.

a. Purely corneal $(A = C)$.

b. Past corneal and Past Extracorneal $(A \quad C)$.

c. Where part or whole of corneal astigmatism is neutralized by extracorneal factors $(A \quad C)$.

4. Effects of Trachomatous scarring in producing corneal astigmatism and its consequent neutralization by extracorneal factors particularly sclerosis of the lens is discussed.

5. Evaluation of total astigmatism from corneal astigmatism is discussed and is concluded that no single rule can be made for all cases in all age groups.

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