Predicting Refractive Astigmatism With the Keratometer

David C. McClintic
Opt.
May 4, 1979

Predicting Refractive Astigmatism With the Keratometer

Abstract

Fifty patients have their Keratometer readings compared to their refractive errors. Javal's rule is applied to investigate if this can be used clinically to determine the patient's correcting cylinder.

Introduction

Javal invented the Keratometer about 1880, after this he formulated his rule in an attempt to correlate the dioptric difference in the two principal meridans of the anterior surface of the cornea with the total astigmatism of the eye as determined by objective and subjective means. The difference between these two findings has frequently led to the significance of the Keratometer as being questioned.

Javal's rule may be stated as:

Total astigmatism equals 0.50 diopters against the rule combined with 1.25 times the amount of astigmatism measured with the Keratometer (astigmatism = -0.50 axis 0 90 + 1.25 (Keratometer readings)). Javal recognized the short comings of his formula by saying that neither .50 diopters against the rule or 1.25 is definitely established and that a new factor possibly expressing a function of age may have to be added. Javal based his constants (he needed to incorporate the astigmatism due to the crystalline lens) on Bull's work and his own work of measuring the astigmatism.

The purpose of this study is to investigate the clinical application of Javal's rule and some possible reasons why it fails to hold up.

Procedure

Fifty patients (100 eyes) were selected from the general population of the State Prison of Southern Michigan. These patients were all between the age of eighteen and twenty five years old. Another criterion that was to be met was that all of these subjects were to have the principal meridians within ten degrees of 90 and 180.

The subjects presented to the optometry clinic at S.P.S.M. and were examined by fourth year Optometry students, supervised by clinical associates (practicing O.D.'s). The Keratometry readings were taken twice and a routine visual examination including objective and subjective refraction followed.

Results and Discussion

See pages 3, 4, 5

K's Horizontal	K's Vertical	Corneal Cyl	Javal's Expected	Refraction	difference
42.37	44.50	2.13 wtr	2.16 wtr	1.75 wtr	-.37
41.50	45.00	3.50 wtr	3.87 wtr	3.50 wtr	-.37
44.00	44.50	0.50 wtr	0.125 wtr	sph	-.12
44.00	45.00	1.00 wtr	0.75 wtr	sph	-.75
41.25	43.75	2.50 wtr	2.62 wtr	2.00 wtr	-.62
40.75	44.37	3.62 wtr	4.02 wtr	2.50 wtr	-1.50
40.50	41.00	.50 wtr	0.125 wtr	0.50 wtr	+.37
40.25	41.25	1.00 wtr	0.75 wtr	0.50 wtr	-.25
42.75	44.12	1.37 wtr	1.25 wtr	1.25 wtr	
42.75	44.25	1.50 wtr	1.37 wtr	1.00 wtr	-.37
43.75	44.12	.37 wtr	sph	sph	
44.12	45.00	.87 wtr	0.50 wtr	sph	-.50
43.00	44.00	1.00 wtr	0.75 wtr	0.50 wtr	-.25
41.75	43.50	1.75 wtr	1.62 wtr	0.75 wtr	-.875
42.50	44.12	1.62 wtr	1.50 wtr	1.75 wtr	+.25
40.50	43.50	3.00 wtr	3.25 wtr	2.75 wtr	-0.50
41.75	45.37	3.62 wtr	4.00 wtr	3.75 wtr	-0.25
44.00	45.00	1.00 wtr	0.75 wtr	sph	-0.75
44.12	44.12	sph	0.50 atr	sph	+0.50
44.87	45.25	.37 wtr	sph	0.25 wtr	+0.25
42.62	42.62	sph	0.50 atr	0.25 atr	+0.25
42.50	42.50	sph	0.50 atr	0.25 atr	+0.25
42.50	43.00	0.50 wtr	0.125 wtr	sph	-0.125
42.75	43.25	0.50 wtr	0.125 wtr	sph	-0.125
42.00	42.75	0.75 wtr	0.37 wtr	0.25 wtr	-0.125
41.50	44.00	2.50 wtr	2.62 wtr	2.50 wtr	-0.125
41.00	42.00	1.00 wtr	0.75 wtr	0.25 wtr	-0.50
41.50	41.50	sph	0.50 atr	sph	+0.50
46.00	46.00	sph	0.50 atr	0.25 wtr	+0.75
46.00	46.75	0.75 wtr	0.50 wtr	1.00 wtr	+0.50
44.50	44.50	sph	0.50 atr	0.25 atr	+0.25
44.75	44.75	sph	0.50 atr	0.50 atr	
43.25	44.25	1.00 wtr	0.75 wtr	0.25 atr	-1.00
43.25	44.50	1.25 wtr	1.00 wtr	0.50 atr	-1.50
41.50	42.00	0150 wtr	.12 wtr	0.75 wtr	+.62
41.50	42.00	0.50 wtr	.12 wtr	1.00 wtr	+.87

K's Horizontal	K's Vertical	Corneal Cyl	Javal's Expected	Refraction	Difference
42.75	43.50	0.75 wtr	.50 wtr	1.00 wtr	+.50
42.50	44.25	1.75 wtr	1.62 wtr	1.25 wtr	-.37
39.12	39.12	sph	.50 atr	sph	+.50
38.87	39.50	.62 wtr	.25 wtr	sph	-.25
42.00	43.00	1.00 wtr	.75 wtr	sph	-.75
41.50	43.00	2.50 wtr	2.62 wtr	2.25 wtr	-.37
44.00	45.00	1.00 wtr	.75 wtr	0.50 wtr	-.25
43.50	45.00	1.50 wtr	1.37 wtr	1.25 wtr	-.12
42.25	43.12	.87 wtr	0.62 wtr	1.00 wtr	+.37
42.62	43.00	.37 wtr	sph	0.75 wtr	+0.75
41.00	41.75	.75 wtr	.50 wtr	0.50 wtr	-
40.75	41.50	.75 wtr	.50 wtr	0.25 wtr	-0.25
43.00	43.00	sph	.50 atr	sph	+0.50
43.25	44.00	.75 wtr	.50 wtr	0.50 wtr	-
44.50	45.00	.50 wtr	.12 wtr	0.25 wtr	+.12
44.50	45.00	.50 wtr	.12 wtr	0.25 wtr	+.12
43.75	44.25	.50 wtr	.12 wtr	0.50 wtr	+.37
43.50	44.25	.75 wtr	.50 wtr	0.50 wtr	-
41.62	42.62	1.00 wtr	.75 wtr	0.50 wtr	-0.25
41.50	42.50	1.00 wtr	.75 wtr	sph	-0.75
40.75	44.25	3.50 wtr	3.87 wtr	4.50 wtr	+0.87
42.75	43.00	0.25 wtr	.12 atr	sph	+.12
42.50	43.00	0.50 wtr	.12 wtr	.75 wtr	+0.62
42.00	42.75	0.75 wtr	.50 wtr	.25 wtr	-0.25
44.25	44.37	.12 wtr	.37 atr	.25 atr	-0.12
44.37	44.37	sph	.50 atr	.25 atr	+0.25
40.50	40.75	.25 wtr	.12 atr	sph	-0.12
40.62	41.12	.50 wtr	.12 wtr	.25 atr	-.37
40.50	43.75	3.25 wtr	3.50 wtr	2.50 wtr	-1.00
41.00	43.00	2.00 wtr	2.00 wtr	1.50 wtr	-0.50
45.50	46.00	0.50 wtr	.125 wtr	.75 wtr	+0.62
45.50	46.00	0.50 wtr	.125 wtr	.75 wtr	+0.62
44.50	50.00	5.50 wtr	6.37 wtr	4.75 wtr	-1.62
44.25	46.25	2.00 wtr	2.00 wtr	1.75 wtr	-0.25
43.00	43.50	0.50 wtr	.125 wtr	1.50 wtr	+1.32
43.00	44.00	1.00 wtr	.75 wtr	1.50 wtr	+0.75

K's			Javal's		
Horizontal	Vertical	Corneal Cyl	Expected	Refraction	Difference
40.00	40.00	sph	0.50 atr	1.00 atr	+0.50
40.00	40.00	sph	0.50 atr	1.50 atr	+1.00
40.75	44.25	3.50 wtr	3.87 wtr	4.50 wtr	+.62
42.75	43.00	.25 wtr	.12 atr	sph	-0.12
43.25	44.00	.75 wtr	.37 wtr	.25 wtr	+.62
43.50	44.12	.62 wtr	.25 wtr	.25 wtr	-
43.25	43.75	.50 wtr	.125 wtr	.50 wtr	+.37
43.50	43.50	sph	.50 atr	.50 atr	-
43.00	43.00	sph	.50 atr	sph	-0.50
43.00	43.00	sph	.50 atr	shp	-0.50
47.25	47.87	.62 wtr	.25 wtr	1.00 atr	+1.25
47.87	48.12	.50 wtr	.125 wtr	sph	-.125
42.50	42.50	sph	.50 atr	.50 atr	-
42.75	42.75	sph	.50 atr	.50 atr	-
42.25	42.50	.25 wtr	.12 atr	sph	+.125
42.25	42.50	.25 wtr	.12 atr	sph	+.125
42.75	44.25	1.50 wtr	1.375 wtr	2.00 wtr	+.625
45.87	46.25	.62 wtr	.12 wtr	sph	-.125
45.75	45.50	.75 wtr	.37 wtr	sph	-.375
41.00	40.25	.75 atr	1.37 atr	0.50 atr	+.87
41.00	41.00	sph	.50 atr	sph	+.50
44.00	45.50	1.50 wtr	1.37 wtr	1.00 wtr	-.37
43.50	44.50	1.00 wtr	.75 wtr	1.25 wtr	-.50
41.25	41.62	.37 wtr	sph	sph	-
43.50	44.50	1.00 wtr	.75 wtr	.75 wtr	-
43.00	44.00	1.00 wtr	.75 wtr	.50 wtr	-0.25
43.37	43.37	-	.50 atr	sph	-0.50
43.00	43.50	.50 wtr	.125 wtr	0.75 wtr	+0.62

Over all the results show that Javal's rule is approximately correct for showing the relation between the statistical averages of refractive and Keratometric astigmatism. However it would seem that Javal's constant of .50 D. against the rule might be more accurate if it were .62 D. against the rule.

Javal's rule works fairly well when applied the group as a whole but when applied to individual cases, differences as much as 1.50 D. are seen. All of these finding are in close agreement to what Drs. Mote and Fry found in their study. Also when the rule fails to work, the Keratometric findings do not isolate the cause of the error. For example the role played by the sphere in changing the effective power of the cylinder at the cornea is not represented in Javal's formula.

Conclusions

The data seems to indicate that in most cases Javal's rule will give the practitioner a ball park estimate of total astigmatism. The rule seems to hold especially well for corneal astigmatism up to 2.00 D. with the rule. But when the Keratometric astigmatism goes above 2.00 D., the total astigmatism at the cornea approaches the Keratometric astigmatism and finally exceeds it. This suggests a non linear equation might be formulated which might take this into account, though no such relationship is evident here.

Javal mentioned that a factor that included age might be needed. Numerous studies have shown that corneal changes do take place with age. The value of the change is small (about .25 D. every ten years). The direction of this change in the majority of cases toward an increase in with-the-rule up to age thirty or forty. For those beyond this age group, there occurs a change in the opposite direction, that is an increase in against-the-rule astigmatism.

A number of different factors can contribute to the discrepancy between the Keratometric astigmatism and the total astigmatism. Some of these factors are:

1. The accuracy of the testing methods; the

Keratometer is reliable only to $\pm$ 0.25 D. and at best, the refraction is good to $\pm$ 0.12 D.. These add together to give an error of $\pm$ 0.62.

2. Toroidal curvature of the anterior and posterior surface of the crystalline lens.
3. Toroidal curvature of the posterior surface of the cornea.
4. Obliquity of incidence at the various surfaces of the bundle of rays passing into the eye from the point of fixation.
5. An irregularity in curvature of the cornea making it impossible to obtain a Kerotometer reading.

Summary

Although Javal's rule doesn't hold true for all cases, it gives a very good estimation of the correcting cylinder needed. Until more exact measuring instruments are devised that can be applied clinically in as simple a fashion as the Keratometer and Javal's rule, we have few alternatives but to use our current methods.

References

1. Borish, I. M.; Clinical Refraction, Professional Press Chicago, 1974.

2. Mote, H. G. and Fry, G. A.; "The Relation of The Keratometric Findings To The Total Astigmatism of The Eye." Am. J. of Optom. 16 (11) 402-409, Nov. 1939.

3. Mote, H. G. and Fry, G. A.; "The Significance of Javal's Rule." Am. J. of Optom. 16 (10) 362-365, Oct. 1939.

4. Lyle, M.; "Changes in Corneal Astigmatism With Age." Am. J. Optom. and Arch. Am. Acad. Optom. 51 (6) 467-478, 1971.

5. Anstice, J.; Astigmatism - Its Components and Their Changes With Age." Am. J. Optom. and Arch. Am. Acad. Optom. 51 (12) 1001-1006, 1971.

6. Javal, E.; Memoires d' Ophthalmometrie. 130 (1890).

7. Bull, G. J.; Memoires d' Ophthalmometrie. (Edited by E. Javal), 437 (1890).

8. Bier, N.; Louther, G. E.; Contact Lens Correction, Butterworth & Co. Ltd., London, 1977.