The Tonomat Applanation Tonometer

Clinical Comparison with the Schiotz Tonometer

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This study is an evaluation of a new tonometer: the Tonomat. Like its prototype, the Maklakov tonometer, the Tonomat is a hand-held, constant-force applanation tonometer. The Tonomat, designed by us, is intended to meet present-day requirements for ease of handling, precision of construction, and hygienic standards. Having no moving parts, the instrument is always in calibration and is, for all practical purposes, friction-free in its action.

Three years ago, we introduced another version of the Maklakov tonometer, the Applanometer, which has ceramic endplates that can be sterilized by flaming.[1,2] In the case of the Tonomat, sterilization procedures have become obsolete, because the endplates are disposable, and a clean, new endplate is used for each patient. Any possibility of cross-infection is thus eliminated.

The Tonomat and its separate parts are shown in Fig. 1. The working portion is a metal probe which slides freely within a tubular handle. The lower end of the probe bears the detachable plastic endplate. The diameter of the endplate is 9 mm, while its applanating surface is slightly smaller, with a diameter of 8.7 mm. Two small depressions, placed marginally and at diametrically opposite points of the endplate, serve to orient the impression made by the cornea with reference to its horizontal or vertical meridian. This feature should prove especially useful in cases of high astigmatism and other irregularities of the corneal curvature.

The probe is made of stainless steel and consists of a rod-shaped plunger and a cylindrical collar. The collar forms the upper end of the probe and serves to retain it within the handle; it also helps stabilize the probe as it approaches the eye. The entire probe assembly, including the endplate, weighs 5 grams.

The tubular handle of the Tonomat acts as a guide for the assembly by allowing it to slide freely within the handle after the endplate has come to rest on the cornea.

METHOD

The sample upon which this study is based consisted of 500 eyes tested with the Tonomat and the electronic Schiotz tonometer. All measurements were made by the same operator. Two drops of proparacaine hydrochloride (Ophthetic) 0.5% were instilled into each eye 2 minutes before beginning the measurements.

First, the Tonomat was used on each patient and then the Schiotz tonometer. The patient was placed in a supine position and was directed to gaze at a fixation target situated directly overhead, 1 meter above his fixing eye. The right eye was always tested first.

The Tonomat employed was representative of the current production model.* Four measurements were made on each eye, a new disposable endplate being used for each patient. Every endplate was inspected to ascertain that it was free of imperfections, particular attention being paid to the applanating surface. No defective endplates were encountered in the entire series.

The applanating surface of the endplate was coated, by means of a cotton-tipped applicator, with a viscous suspension of mild silver protein, N.F., Lot #16506. The instrument was poised 2mm above the cornea for about 2 seconds, and was then lowered slowly onto the center of the cornea. The weight of the plunger was allowed to rest on the cornea for a fraction of a second and the tonometer was immediately lifted in a vertical direction.

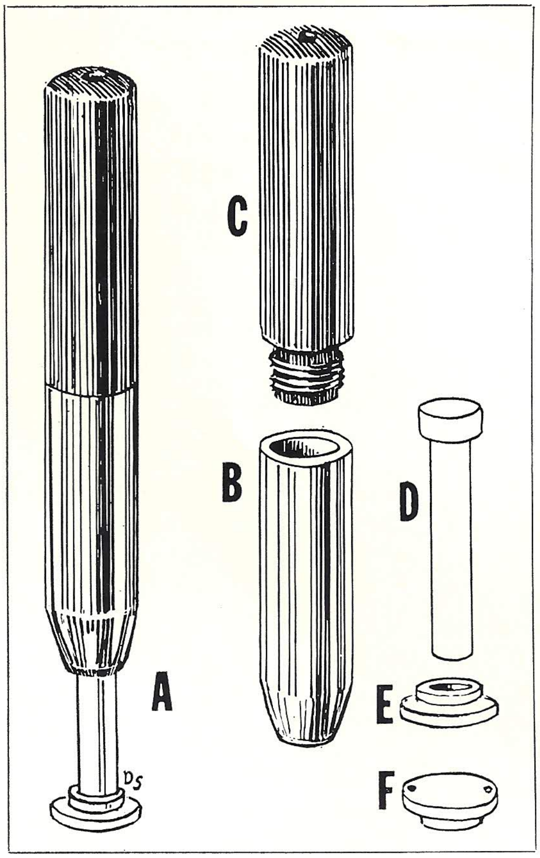

Fig. 1: The Tonomat applanation tonometer. A shows the instrument ready for use. B and C show the two-part tubular handle. D is the stainless steel probe, consisting of shaft and retaining collar. E and F present two views of the disposable plastic endplate; F shows the two orientation markers on the applanating surface. D and E (together) constitute the probe assembly; they weigh 5 grams.

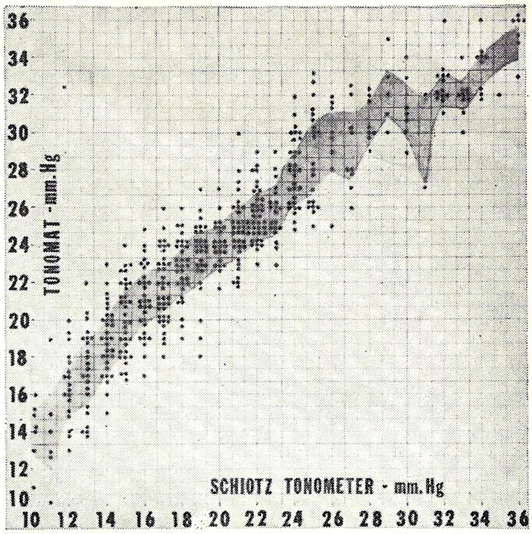

Fig. 2: Scattergram of measurements on 487 eyes tested with the Tonomat applanation tonometer and the electronic Schiotz tonometer. Measurements show a nearly parallel relationship and demonstrate a good correlation, with a low degree of scatter (dark band) between 10 and 25 mm Hg.

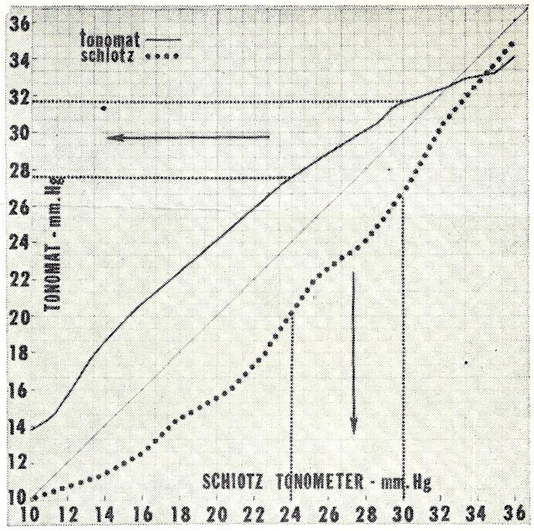

Fig. 3: Simplified graph to show the relationship between the mean measurements of each of the two tonometers. Note that the curves are nearly parallel to each other and symmetrical with respect to the regression line. The graph also demonstrates the generally lower readings obtained with the Schiotz tonometer. This discrepancy reflects the differences in the conversion tables rather than in the performance of the two instruments.

A strip of the record-transfer paper designed for use with the Tonomat was moistened with tap water and any excess water was removed by blotting. The imprint was transferred from the endplate to the moistened paper, using firm pressure.

The intraocular pressure was then determined from the diameter of the applanated area, as measured on the transferred imprint. For this purpose we used an 8-power measuring magnifier equipped with a reticle of our own design which permits measuring the intraocular pressure in millimeters of mercury, without the need for a conversion table. To accomplish this, the imprint was moved, in contact with the reticle, until the area of applanation fitted perfectly between a pair of mutually convergent, curved lines, so that both lines were tangent to the applanation circle of the imprint.

The Schiotz tonometer used in this study was a certified Mueller electronic tonometer, type MC, #59-H-214. The 5.5 plunger was used in all instances. Measurements were read to within ¼ scale unit and were recorded in terms of mm Hg intraocular pressure, using the 1955 conversion table. The tonometer was adjusted on its own test block prior to each use. At least 10 minutes were allowed as a warm-up period. The Schiotz tonometer was connected with a Powerstat transformer, and the voltage was stabilized at 117 volts, A.C.

STATISTICAL ANALYSIS

Of the 500 sets of measurements made in this study, 487 were subjected to statistical analysis. Among those omitted were 4 eyes with high myopia and 9 eyes with tensions either below 10 mm Hg or above 36 mm Hg; their number was insufficient to permit statistical conclusions.

The readings obtained with the Schiotz tonometer were sorted into pressure increment groups. Each set of 4 Tonomat measurements was averaged, and the average value was inserted into the corresponding increment group. This method of analysis was adopted to show the relationship between the two tonometers in terms of Schiotz measurements. The conversion tables accompanying the instruments were used merely as standards of reference, and any discussion of their relative merits would be outside the scope of this paper.

RESULTS

Comparative tonometric measurements on 487 eyes, when plotted in the form of a scattergram, show a nearly parallel relationship between the Tonomat and the electronic Schiotz tonometer (Fig. 2).

The variations in the comparative measurements are shown for each pressure increment as the mean deviation of the mean ocular tension expressed in mm Hg. The scatter varies between ± 0.5 mm Hg, and ± 2.35 mm Hg, and appears to be fairly uniform between 10 and 30 mm Hg (Schiotz). Beyond 30 mm Hg, the graph shows a decrease in scatter, but this may be only apparent and may be due to the small number of measurements recorded in this pressure range.

The Tonomat yielded values which were approximately 4 mm Hg higher than the corresponding Schiotz values in the pressure range between 10 and 25 mm Hg. This difference which reflects the discrepancy between the conversion tables, decreased to 1 to 3 mm Hg in the range between 26 and 37 mm Hg. This progressive decrease in the discrepancy between the two instruments with increasing intraocular pressure is represented in the scattergram by the change in the general slope of the plotted data.

Fig. 3, which represents the average values for each pressure increment group, expresses the relationship between the two instruments even more graphically. It shows again that the difference is approximately 4 mm Hg between 10 and 25 mm Hg (Schiotz), and 1 to 3 mm Hg in the higher pressure ranges.

It may be stated in summary, that in almost every instance the Tonomat yielded higher values than did the Schiotz tonometer.

DISCUSSION

A comparison of the two methods of tonometry has demonstrated to us the relative advantages of the Tonomat over the Schiotz tonometer. The short contact time (a fraction of a second) required to obtain the measurement, and the relatively large size of the applanating surface combine to make the Tonomat a less traumatizing instrument than the Schiotz tonometer. On several patients (not included in this study), we examined the cornea with the slitlamp following the use of each tonometer to determine whether any staining of the cornea could be detected with fluorescein. In no instance was there any corneal staining after the Tonomat, whereas, after the Schiotz tonometer, the entire outline of the plunger was visible in nearly every case.

A disposable applanating plate, moreover, provides a safe, convenient method for eliminating any possibility of cross-infection, and also provides a method which can be used in the presence of an infection.

The statistical results of the present study indicate that there is a good correlation between the Tonomat applanation tonometer and the Schiotz tonometer. The averaged, grouped values obtained with the Tonomat show a high degree of reproducibility within each pressure increment group, and a low mean deviation, or scatter, in the pressure range between 10 and 37 mm Hg.

Some patients, particularly those with high myopia, in whom the difference between Tonomat and Schiotz measurements was much greater than average, were not included in this series because their number was too small for statistical analysis. It was in these cases, however, that we were especially impressed with the need for an applanation-type tonometer, even if only to test the validity of our Schiotz measurements.

In most instances, the difference between the Tonomat and Schiotz readings was of the same order as that found when other applanation tonometers were compared with the Schiotz tonometer. This is because the characteristics displayed by the Tonomat are peculiar not to the instrument as such but to the method of applanation tonometery in general. More specifically, the discrepancy between Tonomat and Schiotz readings is composed of two elements: one dependent on the 1955 Schiotz conversion tables, the other dependent on the position of the patient. The former plays the more significant role by far.

The epidemiologic studies of Schwartz,[3] demonstrate most dramatically the discrepancies between the Schiotz tonometer and the Goldmann applanation tonometer in both patient positions: sitting and supine. In one series of 502 subjects, the Schiotz measurements were 4 mm Hg lower than supine applanation measurements in the range between 14 and 22 mm Hg. A second population survey yielded similar findings.

Our own measurements with the Tonomat and the Schiotz tonometer, both used with the patient in the supine position, bear out this relationship by showing a 4 mm Hg higher mean value for the Tonomat in the pressure range between 10 and 25 mm Hg.

The studies of Schwartz[4] also show that the Goldmann applanation tonometer gives values which are about 2 mm Hg higher when it is used in the supine position than when it is used in the sitting position. We, too, have been cognizant of this difference and, in fact, one of us (Inglima)[5] has studied the effect that patient position has on the tonometric measurement. These studies, using the Applanometer, showed that, although the supine readings were on an average slightly higher than the semi-recumbent readings, the relationship was not consistent; the difference tended to be significantly greater in glaucomatous eyes and in eyes with abnormally low coefficient of outflow.

In his most recent, as yet unpublished study, in which the Applanometer was included in addition to the three methods used previously, Schwartz[4] found that the mean values for the Applanometer fell halfway between the sitting and supine measurements made with the Goldmann applanation tonometer.

In accordance with these findings, which corroborate those derived from our own clinical experience, the conversion table for the Tonomat was recalibrated in 1966 so as to bring it into better agreement with the Goldmann applanation tonometer (sitting). This change affects only pressures in the low and medium ranges, and the corrected values are approximately 1mm Hg lower.

SUMMARY

The Tonomat, a new hand-held applanation tonometer of the authors' design, was compared with the electronic Schiotz tonometer on 487 subjects.

In the range of 10 to 25 mm Hg (Schiotz), the means of the values obtained with the two tonometers showed a nearly parallel relationship. The Schiotz readings were about 4 mm Hg lower than the Tonomat readings. This difference illustrates the discrepancy between the conversion tables.

The Tonomat uses sterilized, disposable endplates, practically eliminating the possibility of cross-infection.

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FOOTNOTE:
**Supplied by Ocular Instruments, Inc., Seattle, Wash.—Certified by the Institute for Glaucoma Research, Inc., New York.*

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