ROMER FOR USE WITH THE TONOGRAPHIC NOMOGRAM*†

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A ROMER is a measuring card used for determining the grid-reference of a point on a map, and can, therefore, also be used for reading off the rectangular co-ordinates of any point on a graph. The romer here described has been constructed for use with the Tonographic Nomogram based on the 1955 Calibration (Friedenwald, 1937) and published by the Institute of Ophthalmology, London.

Construction

This romer is made from thick cartridge paper, cut with a guillotine to a square measuring 6×6 in. (16×16 cm.). The origin of the romer will be its upper right-hand corner, whereas the origin of the nomogram scales is the lower left-hand corner; therefore, the romer is calibrated in an inverted position with its origin exactly on the origin of the nomogram and the two sides parallel and coincident with the scales of the nomogram. The romer is then re-orientated and the numerals for its scales completed in this position as shown in Fig. 1; the volume of indentation is given across the top and the intra-ocular pressure down the right side. Fig. 1 also shows how it is used on the nomogram for measuring the pressure and volume values corresponding to 10.5 on the 10 g. curve. It is important to orientate the romer exactly so that the pressure and volume readings on the romer scales are equal to the readings on the nomogram scales where the romer intersects.

The central area of the romer is completed with a Table giving the intra-ocular pressure (P_t mm. Hg) for a series of applanation diameters (D mm.) at applanation forces (W g.-weight) from 1 to 8 g.-weight. These values are calculated using the equation:

$$P_t = \frac{W \times 93.6}{D^2} \dots \dots \dots (1)$$

For convenience in reading, the applanation diameter values are each connected by a sloping line to the corresponding value (on the upper edge of the romer) of the corneal volume displacement (V_c mm.³). These have been calculated for corneal radii (R mm.) of 7.6, 7.8, and 8.0 mm. (see Table, overleaf, p. 494), using the equation:

$$V_c = \pi. \left[R - \sqrt[3]{(R^2 - Q^2)} \right] \times \left[R^2 - \frac{R^2 + R \cdot \sqrt[3]{(R^2 - Q^2)} + (R^2 - Q^2)}{3} \right], \dots (2)$$

where Q is the radius of applanation in mm. $= \left(\frac{D}{2} \right)$.

The Romer-Table uses the volume displacement values calculated for a corneal radius of 7.8 mm.

* Received for publication May 9, 1967.

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FIG. 1.—The romer applied to the nomogram.

The line of the vertical scale at the right-hand side of the romer is broken to show where the indicator runs down from the curve to the Table.

TABLE

Applanation Radius (mm.)	Intra-ocular Volume (mm. ³) displaced by Applanation of Cornea with Radius of Curvature (mm.)		
	7.6	7.8	8.0
1.00	0.103	0.101	0.098
1.125	0.167	0.162	0.158
1.250	0.255	0.248	0.242
1.375	0.373	0.364	0.354
1.500	0.530	0.516	0.503
1.625	0.732	0.713	0.694
1.750	0.987	0.961	0.936
1.875	1.304	1.269	1.236
2.000	1.693	1.648	1.605
2.125	2.165	2.106	2.051
2.250	2.730	2.656	2.586
2.375	3.401	3.308	3.220
2.500	4.192	4.076	3.967
2.625	5.116	4.974	4.840
2.750	6.189	6.016	5.852
2.875	7.427	7.217	7.019
3.000	8.848	8.595	8.357
3.125	10.470	10.169	9.884
3.250	12.315	11.956	11.619
3.375	14.402	13.978	13.580
3.500	16.757	16.258	15.790
3.625	19.407	18.817	18.268
3.750	22.367	21.683	21.042
3.875	25.678	24.882	24.138
4.000	29.367	28.444	27.582

Applications of the Romer

The author has found the romer useful in three methods connected with tonography:

(1) Indentation Tonography using the Nomogram

There are several methods for calculating the co-efficient of outflow (Gloster, 1965a) and possibly Tables are used most frequently. However, the modern electronic tonometer can be read to an accuracy of between 0.2 or 0.1 of the Schiøtz scale and it is easier to interpolate between the 0.5 Schiøtz readings on the nomogram than with the outflow Tables. The romer can be used to read off the volume and pressure values corresponding to any point on a calibration curve, and the differences ($\Delta V_s, \Delta P$) give the change in volume due to indentation and the change in pressure respectively.

The change in volume due to scleral contraction (ΔV_s) may be calculated using the co-efficient of ocular rigidity (Friedenwald, 1937).

$$\Delta V_s = (\log_{10} P_{t0} - \log_{10} P_{t4})/K, \quad \dots \dots \dots (3)$$

where P_{t0} is the intra-ocular pressure at the beginning of tonography, P_{t4} is the intra-ocular pressure four minutes later at the end of tonography, and K is the co-efficient of ocular rigidity, which is sometimes assumed to be 0.0215.

ΔV_s can be calculated easily and rapidly on a slide-rule, which has a scale of logarithms, base = 10 (as for example the Faber-Castell 67/54b pocket rule).

The outflow co-efficient (C) is calculated directly using these three values and the applanation reading (P_{app})

$$C = \frac{\Delta V_c + \Delta V_s}{\left(\frac{P_{t0} + P_{t4}}{2} - P_{app} - 1.25 \right) \times T} \quad \dots \quad (4)$$

where 1.25 mm. corrects for the elevation of episcleral venous pressure (Linnér, 1955) and $T = 4$ minutes is the usual period of tonography.

(2) Ocular Rigidity using a Differential Applanation Tonometer

The doubling prism used in the Goldmann applanation tonometer allows measurement of the intra-ocular pressure only at a fixed area of applanation (7.354 mm²), and therefore a fixed volume displacement (approximately 0.56 mm.³). In order to calculate the ocular rigidity, there must be at least one more measurement of intra-ocular pressure at a greater volumetric displacement and this has been made possible by using an alternative plastic cylinder in the tonometer; the cylinder has a scale across the distal end allowing measurement of the diameter of applanation up to 11 mm.

The Table within the romer has values of intra-ocular pressure for a variety of applanation weights and diameters, and these have been used to construct calibration curves, such as those in Fig. 2.

These curves have the same physical meaning as the calibration curves for the Schiøtz tonometer and can be used in the same way for measuring the co-efficient of ocular rigidity, K (Gloster, 1965b).

A simple routine is to measure the intra-ocular pressure first using the doubling prism, which is then replaced by the measuring cylinder. The tonometer is then set to 8-g. weight and applanation is repeated, this time measuring the diameter of applanation. The gradient of the line joining the applanation pressure (at 3.06 mm.) to the applanation diameter for 8 g. on the 8-g. curve is measured using the ocular rigidity scale.

This method of measuring ocular rigidity produces less elevation of intra-ocular pressure and the co-efficient has been found generally to be higher, as one would expect from previous work on excised eyes (Draeger, 1960; Perkins and Gloster, 1957). As tonography is usually performed within this lower range of pressures, this method of estimating the co-efficient of ocular rigidity may sometimes provide a more accurate parameter for calculating the outflow.

(3) Applanation Tonography

Various methods of tonography have been described using the applanation tonometer during the whole period of the estimation (Gloster, 1962; Goldmann and Schmidt, 1965). These use a separate compression device to produce the necessary elevation of intra-ocular pressure above the steady-state pressure, although it is possible to achieve a sufficient increase in pressure by a larger area of applanation.

The author has used the plastic measuring cylinder described above with a constant force of 8 g., and has measured the rate of increase of applanation area using a stop-watch. This method is comparable to the method using a Schiötz tonometer, and the 8-g. curve on the nomogram is used to estimate the volume and pressure values for the beginning and end of the period of tonography. The co-efficient of outflow is then calculated using the Equation (3) above (see Fig. 3, opposite).

This method has not the accuracy of that using an electronic tonometer, but it has proved useful for patients, such as those with chronic bronchitis, in whom the usual supine position produces dyspnoea and coughing.

Summary

A romer is described which is used to construct applanation calibration curves on the tonographic nomogram. Methods of using these curves for estimating the co-efficients of rigidity and outflow are also described.

I am grateful to my colleagues at the Wolverhampton Eye Infirmary for the help they have given me in referring their patients to the Glaucoma Clinic, where these methods have been developed, and to Messrs. Keeler Ltd., who supplied the measuring applanation cylinder to my specifications. The Table was calculated on the Birmingham Regional Hospital Board computer.

REFERENCES

- DRAEGER, J. (1960). *Ophthalmologica (Basel)*, **140**, 55.
 FRIEDENWALD, J. S. (1937). *Amer. J. Ophthalm.*, **20**, 985.
 GLOSTER, J. (1962). *Trans. ophthalm. Soc. U.K.*, **82**, 315.
 ——— (1965a). "Tonometry and Tonography". *Int. Ophthalm. Clin.*, **5**, No. 4, chap. XII, p. 1020 (The basis of tonography).
 ——— (1965b). *Idem*, chap. VII, p. 969 (Differential tonometry and the clinical measurement of ocular rigidity).
 GOLDMAN, H., and SCHMIDT, T. (1965). *Ophthalmologica (Basel)*, **150**, 65.
 LINNÉR, E. (1955). "Acta XVII Conc. Ophthalm., 1954, Canada, U.S.A.", vol. 3, p. 1532.
 PERKINS, E. S., and GLOSTER, J. (1957). *Brit. J. Ophthalm.*, **41**, 93; 475.