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Committee Chair

M. Stephen Martin

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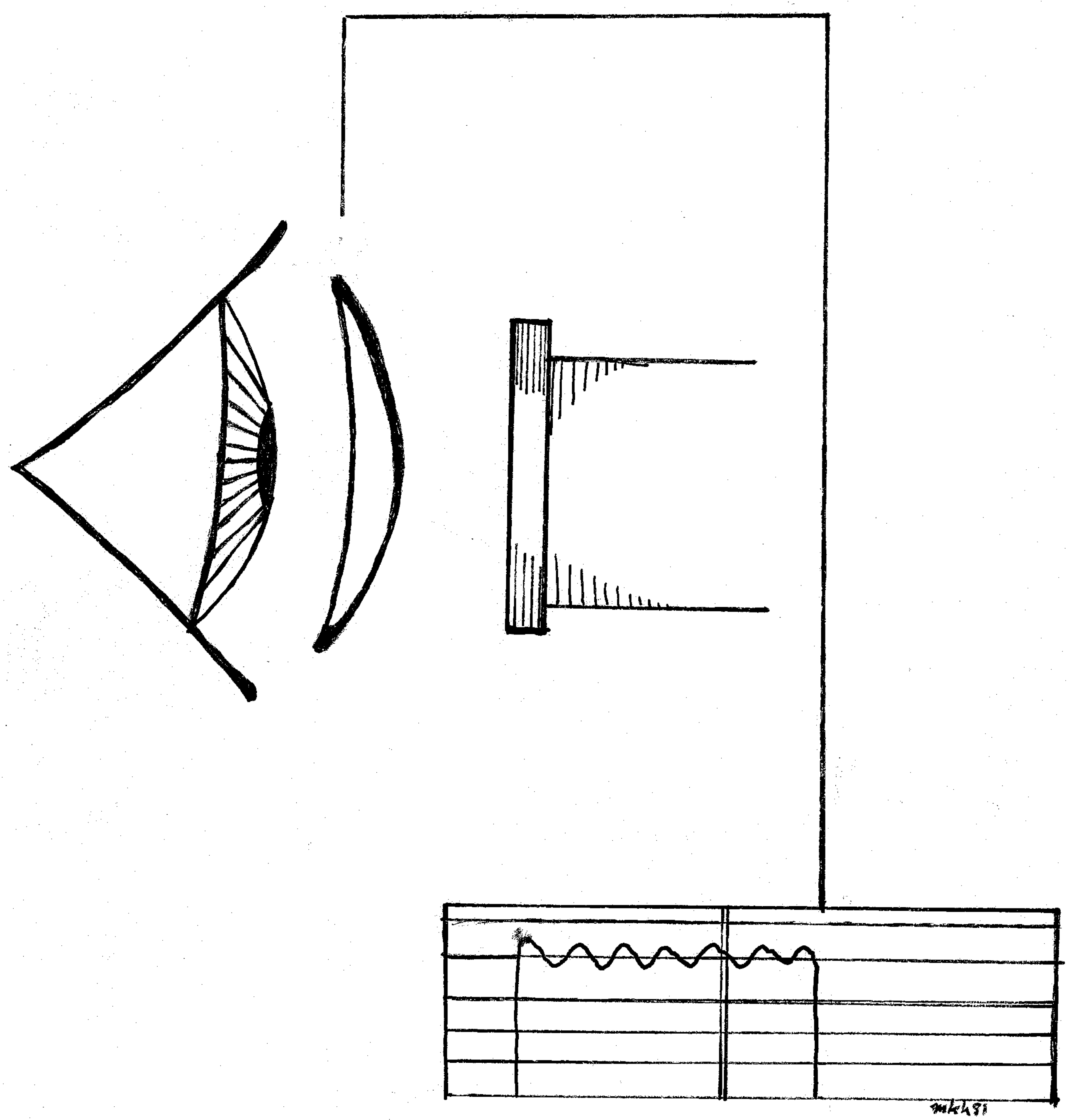
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EFFECTS OF SOFT CONTACT LENSES AS AN ALTERNATIVE TO TOPICAL ANESTHESIA WHEN UTILIZING THE PNEUMA-TONOMETER

BY

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DECEMBER 10, 1980

PACIFIC UNIVERSITY COLLEGE OF OPTOMETRY

Grade Sheet

Title: Effects of Soft Contact Lenses as an Alternative to Topical Anesthesia When Utilizing the Pneuma-Tonometer

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Midterm Grade: A

Final Grade: A

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Acknowledgements

We wish to thank Bausch and Lomb Soflens Division, American Optical, and Hydrocure II for their help through complementary soft contact lenses. We also would like to thank PTU optometric fraternity and the Oregon Optometric Association for financial support. The students of Pacific University who served as subjects and advisor Dr. M. Stephen Martin receive many thanks because without their help, this study could not have been performed. And last but not least, we wish to thank Digilab for the use of their Pneuma-Tonometer which they very generously donated to the Pacific University College Optometry Special Procedures Clinic.

Abstract

The purpose of this study was two-fold. We attempted to determine if valid intraocular pressure readings could be obtained when utilizing the Digilab Pneuma-Tonometer over a soft contact lens in place of an anesthetic on a patient's eye. We also attempted to determine the nature of any difference in patient sensation between utilizing the tonometer with a soft lens versus utilization with a topical corneal anesthetic.

Our results indicated that soft lenses allow accurate readings over a range of normal pressures. We also found that no significant difference in sensation existed between the two conditions (contact lens versus anesthetic). We found that utilizing a soft lens during the tonometric procedure was surprisingly uncomplicated, even on inexperienced patients.

The results of this study suggest that the technique of utilizing soft lenses with the Pneuma-Tonometer is practical and will yield valid readings over a normal range of pressures.

Tonometry is an indispensable part of a complete ocular health examination because it is a screening procedure for glaucoma, an insidious disease that affects approximately two percent of the population over the age of forty. Early detection is important since prompt treatment can prevent the well known consequences of advanced glaucoma--visual field loss, low vision, and blindness. For this reason, many methods for measuring intraocular pressure have been developed over the years.

Goldmann applanation tonometry is widely accepted as the most accurate method of measuring intraocular pressure,[1] as well as being highly repeatable.[2,3] Goldmann tonometry is the standard by which the accuracy of other tonometers is often compared. Measurements from the latest model of the Pneuma-Tonometer (Digilab model 30-R) have been shown to correlate highly with Goldmann tonometer readings.[4,5]

The advantages of the Pneuma-Tonometer include its relatively low cost when compared to similarly accurate methods, its portability (excellent for bed-ridden patients), the fact that little practice is required for accurate readings to be obtained with the instrument, the permanent records obtained through the instrument's readout, and the readout of the ocular pulse allowing measurement of pressure at the average pulse value rather than a single reading taken at the high or the low point.[6]

One disadvantage of both the Goldmann and the Pneuma-tonometer methods of IOP measurement is the fact that both procedures require the use of a topical anesthetic and only twenty-four states have passed DPA laws allowing the use of topical anesthetics by optometrists. Also, the use of an anesthetic is contraindicated when a drug allergy is present, as well as when the corneal epitheliun is in a vulnerable condition, such as being edematous, eroded, or abraded.

Topical anesthetics have been reported to cause epithelial edema and increase epithelial permeability.[7] Other reactions known to occur include inhibition of epithelial cell migration and multiplication (the healing process), drying of the cornea as a result of an inhibited blink reflex, transient conjunctival vasodilatation, stinging, and burning. An infrequent severe epithelial reaction has been reported, resulting in 20/200 visual acuity in five to thirty minutes.[8] Safe anesthetics have been developed which minimize these side effects, but they still occasionally exist.

Use of an anesthetic is not desirable in patients currently wearing contact lenses. Since tonometry is usually performed last in an examination, it would be more convenient if contact lens wearers could reinsert their lenses immediately after tonometry, and it would be extremely convenient if they did not have to remove the lenses at all.

In states with no DPA law, or when an accurate estimate of the IOP is needed but an anesthetic is contraindicated, an alternative procedure is necessary. One such alternative method has been suggested: tonometry performed over a soft contact lens.[9] This method, if accurate, would be very valuable in cases where IOP measurement is needed with a therapeutic soft lens in place, or when the corneal epithelium is disrupted. Especially important is the fact that glaucoma may cause epithelial edema and corneal bullae, and IOP measurement is necessary for diagnosis.[10] It would also be convenient for regular contact lens wearers, as mentioned previously.

Deluca, et. al. in 1974 performed many forms of tonometry through a soft lens, but they were unable to successfully determine IOP through the soft lens utilizing the Goldmann tonometer.[11] They did not investigate the Pneuma-Tonometer. Polse, et. al. in 1976 successfully measured IOP through soft lenses on rabbit eyes utilizing the MacKay-Marg and Schiotz tonometers. They found their readings to be valid over a wide range of pressures.[12]

Krieglstein, et. al. in 1976 used the pneumotonograph to take pressure readings over Titmus soft contact lenses placed on eyes with chronic corneal diseases.[13] The readings were found to be accurate and reliable except for soft lenses of higher powers.

Purpose and Background

This study will attempt to show that various brands of modern soft lenses will afford valid readings on human eyes utilizing the Pneuma-Tonometer. It will also compare the subjective evaluation of the comfort of the procedure utilizing a lens rather than an anesthetic. Through these observations, we will be able to judge the practical value of the procedure.

A background on how the tonometer works will precede our assumptions and methodology.

The Pneuma-Tonometer, manufactured by Digilab, is designed to accurately measure intraocular pressure. This is measured by a pneumatic pressure balancing system. The system is established by an equilibrium between gas pressure (Freon 12) and the intraocular pressure.

Please refer to Figure 1. Gas initially enters a small tube (Figure 1a), which then passes through minute pores to form an "air bearing" (b) (frictionless flotation) for the piston. The piston is propelled forward by the gas until the anterior silastic membrane (c) applanates the eye. Escape of gas on the contraocular tip (d) is impeded until the pressure pushing behind the probe is proportional to the intraocular pressure, and thus in turn, is recorded by the instrument (e).

Calibration is checked to the zero line between each measurement. (see Figure 2).

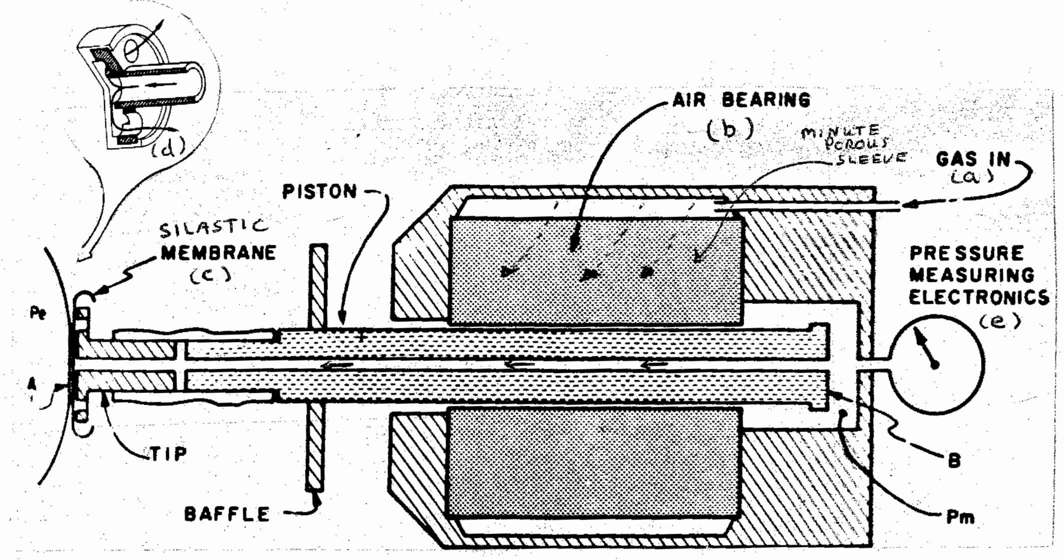


Figure 1

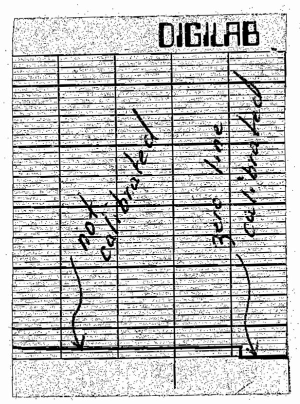


Figure 2

The sensor probe is then held perpendicular to the cornea for a minimum of five seconds until an audible signal is heard. This informs the operator of proper eye contact and correct recording alignment.

Measurements are taken on moving graph paper which allows permanent records in direct mm. Hg. The "ripples" recorded correspond to the patient's ocular pulse (refer to Figure 3). The midpoint of the ripple is the intra-ocular pressure (IOP).

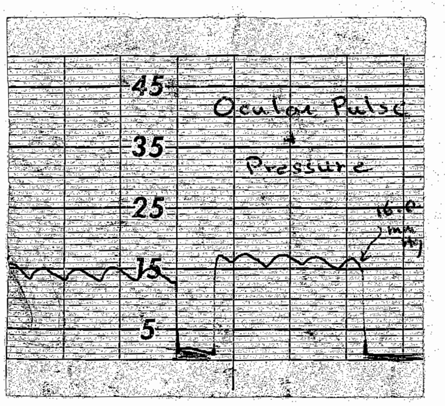
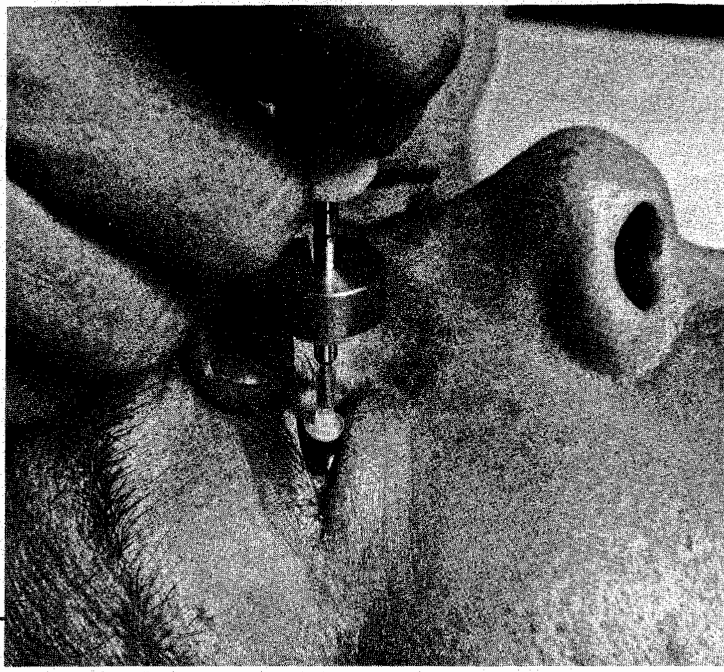


Figure 3

unique...

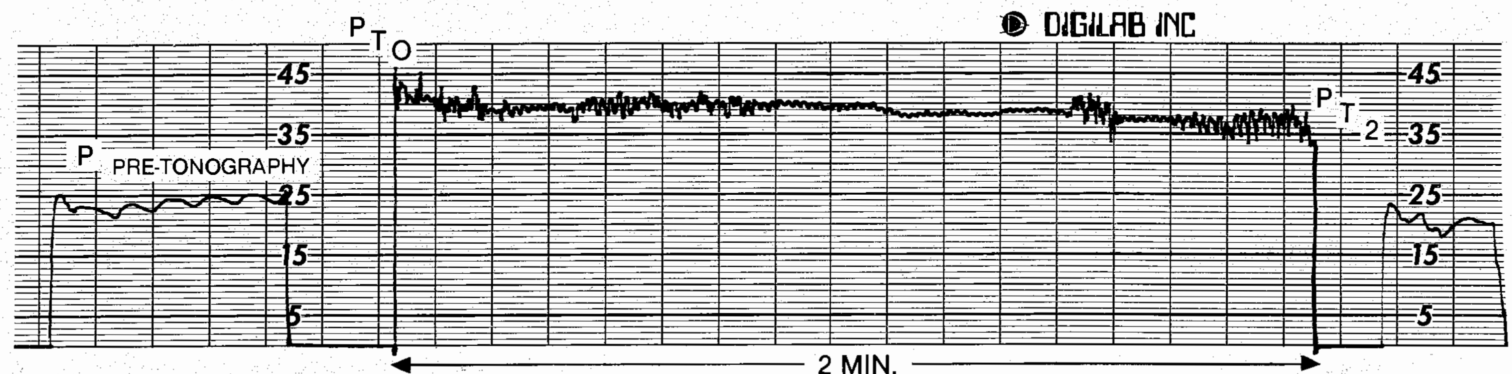
DIGILAB Model 30R/T
Pneuma-Tonometer/Tonographer



DIGILAB Model 30R/T Pneuma-Tonometer/ Tonographer

Pictured is the ten gram weight added to the sensor which increases the intraocular pressure by flattening the cornea along the peripheral edge of the sensor tip. At the same time, the center of the tip measures the true intraocular pressure, unlike indentation tonography which does not measure the actual pressure.

DIRECT INTRAOCULAR PRESSURE MEASUREMENT DURING TONOGRAPHY



Typical Patient Tonograph

The Digilab Model 30R/T is a dual purpose precision instrument for measuring intraocular pressure and performing tonography. The Model 30R/T has all the advantages of the Digilab Model 30 Series Tonometers: Permanent patient record, measurement of ocular postural response, ocular pulse amplitude and a calibration verifier. In addition, the Model 30R/T can perform tonography, directly measuring the intraocular pressure during the procedure.

The coefficient of outflow -C value is easily derived from the simplified tables or by direct calculation. The accuracy of the determination of C is increased two ways, by the addition of a P_{TO} column to the table and by directly measuring the intraocular pressure during tonography for the P values. When using the tables if the P_{TO} value for the patient differs from the expected, the direct calculation method should be utilized. Accuracy, ease of use and dual function allow the practioner to broaden his diagnostic base with the Digilab Model 30R/T.

Specifications —

This product is made under one or more of the following U.S. patents: No. 3,099,262 and 3,628,526 and 3,714,819 and all foreign patents which apply to this product.

Size: 6¾″ high, 14¾″ wide, 9⅛″ deep
Weight: 18 pounds
Electrical: 50/60 Hz, 230/115 VAC, 130 milliamperes
Gas Supply: 14 oz. can of dichlorodifluoromethan (CCL_2F_2)

DIGILAB
Division of Bio Rad Laboratories
237 Putnam Avenue, Cambridge, MA 02139
Telephone (617) 868-4330 TWX (710) 320-0821

REFERENCES:

1. COMPARATIVE INTRAOCULAR PRESSURE MEASUREMENTS WITH THE PNEUMATONOGRAPH AND GOLDMANN TONOMETER: Harry A. Quigley, M.D., and Maurice E. Langham, Ph.D., American Journal of Ophthalmology, Vol. 80, No. 2, August, 1975.

2. INFLUENCE OF BODY POSITION ON THE INTRAOCULAR PRESSURE OF NORMAL AND GLAUCOMATOUS EYES: Gunter K. Krieglstein and Maurice E. Langham, Ophthalmologica, Basel: 171: 132-145 (1975).

3. PNEUMATONOGRAPHIC STUDIES ON NORMAL AND GLAUCOMATOUS EYES: Maurice E. Langham, Wolfgang Leydhecker, Gunter Kreiglstein, and Wolfgang Waller, Adv. Ophthal., Vol. 32, 108-133 (Karger, Base 1976).

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Methodology

Part I.

The first part of this study had a two-fold purpose: a) to determine if a clinically significant difference exists between IOP readings taken through five brands of soft lenses versus those with anesthetic, and b) to observe which soft lenses that proved most reliable for the procedure.

The five soft lenses utilized were: Hydrocurve II, Bausch and Lomb B3, Bausch and Lomb U4, American Optical Softcon, and American Optical Thin. The parameters are summarized in Table 1. Base curves known to fit the majority of the population were selected. All of the lenses were -3.00D. in power; this again is a population average, and would allow ease of handling due to slightly thicker edges. These lenses would most likely be in every contact lens practitioner's diagnostic lens inventory.

We chose the brands most widely used locally, incorporating both relatively "thick" (0.255mm.) and "thin" (0.050mm.) lenses.

A basic assumption underlies Part I.: the Pneuma-Tonometer is an applanation type device. With applanation tonometry, Borish states, "ocular stresses caused by an indentation instrument, the effect of ocular rigidity, and the necessity to calculate the value P_t into terms of P_o are either eliminated or minified."[14]

Table 1

Contact Lens Parameters

Lens	Material	Center Thickness	Diameter	Power	Base Curve	H_2O Content
HCII	(bufilcon A)	0.05mm.	13.5mm.	-3.00	8.6mm.	45.0%
B3	(polymacon)		13.5mm.	-3.00		38.6%
U4	(polymacon)		14.5mm.	-3.00		38.6%
AO Softcon	(vifilcon A)	0.255mm.	13.5mm.	-3.00	8.4mm.	55.0%
AO Thin	(tetrafilcon A)	0.05mm.	13.8mm.	-3.00	8.6mm.	42.5%

P_t=force applied to eye, pressure in eye artificially increased due to tonometer

P_o=true pressure in eye before tonometer was applied

Borish states that the area applanated "displaces so small a volume of fluid (0.5mm. for a cornea of average radius) that P_t and P_o are very close and clinically almost identical."[15]

Procedure

After the case history, visual acuity, and corneal health assessments were made, three intraocular pressure measurements were taken utilizing anesthetic (0.5% Proparacaine HCL--Ophthaine), on the subject's right eye. This was considered the standard reading. Immediately following this, three readings were taken through each of five soft lenses on the right eye. These readings were then to be compared to the standard. This in turn was followed by another reading on the anesthetized bare cornea, to evaluate the variability of the standard.

Subjects were well aquainted with the use of soft lenses as well as with the procedure of tonometry. Testing was done by three different examiners to obtain measurements on thirteen subjects; each subject had one examiner. Thus, we obtained seven sets of three readings on each subject.

Part II.

Subjects for Part II consisted of a separate population from that of Part I. All subjects were non-contact lens wearers who were not well acquainted with the tonometric procedure. They were evaluated with respect to case history, visual acuity, and corneal integrity. Each subject returned for two visits on separate days; on one visit tonometry was performed once through a soft contact lens on the right eye, and the subject rated the sensation as the probe touched their eye. This was "Trial L". On the other visit, tonometry was performed utilizing an anesthetic and the same sujective evaluation of sensation took place. This was "Trial A". We randomly determined whether Trial A or Trial L came first. Three examiners performed the procedure on twenty-eight subjects; the same examiner administered both trials on a given subject. After applying the topical anesthetic or placing a soft lens on the subject's eye, this statement was made to each subject: "You will be asked to rate the sensation on a scale of one to seven, one causing you the least sensation and seven causing you the most sensation, as the probe touches your eye." Tonometry was then performed, followed by the subject reciting a number between one and seven corresponding to their rating. No other instructions were given.

Three lenses were used in Part II. They were determined easiest to use from Part I. The three lenses were alternated for use in Trial L on each subject, thus we obtained three groups of data for both trials.

Table 2

Data: Part I

Condition	Mean	S.D.	Std. Mean -CL Mean
Subject: SM			
Anesthetic Std.	13.66	0.577	----
HCII	12.66	0.763	-1.00
B3	12.83	0.288	-0.83
U4	13.16	0.288	-0.50
AO Softcon	13.00	0	-0.66
AO Thin	13.00	0.50	-0.66
2nd Anesthetic	12.50	0.50	-1.16
Subject: BD			
Anesthetic Std.	15.80	0.763	----
HCII	15.50	0.50	-0.30
B3	15.33	0.57	-0.47
U4	15.66	0.763	-0.14
AO Softcon	15.16	0.763	-0.64
AO Thin	15.66	0.763	-0.14
2nd Anesthetic	14.50	0	-1.30
Subject: GK			
Anesthetic Std.	15.66	1.52	----
HCII	13.00	1.00	-2.66
B3	15.66	0.57	0
U4	14.50	0.86	-1.16

Table 2 (Cont'd.)

Condition	Mean	S.D.	Std. Mean -CL Mean
Subject: GK (Cont'd.)			
AO Softcon	18.5	0.50	+2.84
AO Thin	14.33	0.57	-1.33
2nd Anesthetic	14.00	0	-1.66
Subject: DM			
Anesthetic Std.	18.50	0	----
HCII	20.30	1.539	+1.80
B3	18.16	1.60	-0.34
U4	20.00	0	+1.50
AO Softcon	20.16	0.763	+1.66
AO Thin	19.33	0.763	+0.83
2nd Anesthetic	21.50	1.32	+3.00
Subject: MH			
Anesthetic Std.	15.66	0.577	----
HCII	14.75	0.433	-0.91
B3	14.08	0.144	-1.58
U4	15.00	0.50	-0.66
AO Softcon	13.66	1.25	-2.00
AO Thin	14.08	0.144	-1.58
2nd Anesthetic	12.66	1.15	-3.00
Subject: RC			
Anesthetic Std.	15.33	0.288	----
HCII	14.166	0.288	-1.16
B3	15.33	1.25	0

Table 2 (Cont'd.)

Condition	Mean	S.D.	Std. Mean -CL Mean
Subject: RC (Cont'd.)			
U4	15.16	0.288	-0.17
AO Softcon	15.00	0	-0.33
AO Thin	15.00	0	-0.33
2nd Anesthetic	14.66	0.577	-0.67
Subject: GK			
Anesthetic Std.	16.33	0.577	----
HCII	14.83	0.288	-1.50
B3	13.33	0.577	-3.00
U4	14.33	0.577	-2.00
AO Softcon	15.00	0	-1.33
AO Thin	13.33	0.577	-3.00
2nd Anesthetic	12.66	0.577	-3.67
Subject: DS			
Anesthetic Std.	14.66	0.577	----
HCII	19.33	0.577	+4.66
B3	15.33	0.577	+0.66
U4	12.66	0.577	-2.00
AO Softcon	12.66	0.577	-2.00
AO Thin	15.33	0.577	+0.66
2nd Anesthetic	14.83	0.763	+0.16
Subject: RS			
Anesthetic Std.	15.16	0.763	----
HCII	14.00	0.50	-1.16

Table 2 (Cont'd.)

Condition	Mean	S.D.	Std. Mean -CL Mean
Subject: RS (Cont'd.)			
B3	14.50	1.32	-0.66
U4	14.66	0.288	-0.50
AO Softcon	15.00	0.866	-0.16
AO Thin	15.00	0	-0.16
2nd Anesthetic	14.83	0.28	-0.33
Subject: NM			
Anesthetic Std.	16.66	0.288	----
HCII	16.33	0.577	-0.33
B3	15.66	0.577	-1.00
U4	16.50	1.32	-0.16
AO Softcon	16.83	1.25	+0.17
AO Thin	15.66	0.577	-1.00
2nd Anesthetic	15.83	0.288	-0.83
Subject: KP			
Anesthetic Std.	15.33	0.577	----
HCII	13.83	0.288	-1.50
B3	15.33	0.577	0
U4	15.33	0.577	0
AO Softcon	16.83	0.763	+1.50
AO Thin	16.33	0.577	+1.00
2nd Anesthetic	14.33	0.577	-1.00
Subject: RB			
Anesthetic Std.	12.00	0.50	----

Table 2 (Cont'd.)

Condition	Mean	S.D.	Std. Mean -CL Mean
Subject: RB (Cont'd.)			
HCII	13.16	1.15	+1.16
B3	12.00	0.50	0
U4	14.16	0.28	+2.16
AO Softcon	11.33	1.25	-0.67
AO Thin	11.16	0.57	-0.84
2nd Anesthetic	11.16	0.20	-0.84
Subject: LA			
Anesthetic Std.	18.16	0.288	----
HCII	19.33	1.154	+1.17
B3	19.33	1.154	+1.17
U4	19.16	0.288	+1.00
AO Softcon	20.16	0.763	+2.00
AO Thin	18.50	0.866	+0.34
2nd Anesthetic	17.84	1.04	-0.32

Table 3

Condition	Mean Total	S.D.	
HCII	0.13	1.91	Series 1
B3	0.47	1.04	Series 2
U4	0.13	1.23	Series 3
AO Softcon	0.03	1.54	Series 4
AO Thin	0.48	1.11	Series 5
2nd Anesthetic	0.89	1.58	Series 6

Table 4 (Cont'd.)

Subject	B3	Anesthetic
JH	3	2
KM	4	3
SD	2	2
LW	1	1*
AG	1	1
LT	2.5	1.5*
PK	1*	1
DK	1	1*
DH	1.5	2.5
ST	2	3
RL	1	1
RH	2	1

Table 5

Comfort: Lens vs. Anesthetic

Lens	Lens Worse	Lens Better	Same
U4	7/9	....	2/9
HCII	3/7	2/7	2/7
B3	4/11	2/11	5/11

Results--Part I.

The procedure previously described was performed on thirteen normal eyes with average pressure ranging from 12.0 mm. Hg to 18.5 mm. Hg. The results of mean intraocular pressures of patients in all six series were compiled (refer to Table 3). The Pneuma-Tonometer reading was taken first with anesthetic and then treated as the standard IOP. In Series 1, the mean pressure difference (anesthetic standard P_a-P_{HCII}) was 0.13 mm. Hg. Series 2 for the B3 was P_a-P_{B3}= 0.47 mm. Hg. Series 3 for the U4 was 0.13 mm. Hg, Series 4 for the AO Softcon was 0.03 mm. Hg, Series 5 for the AO Thin was 0.48 mm. Hg, and Series 6 for the second anesthetic reading (P_a-P_{aII}) was 0.89 mm. Hg.

In the above mentioned series, all passed the t-test to the 0.05 level. (Since this was a two-tailed test, z=0.025). Therefore, none of the readings differed significantly from the standard anesthetic mean.

Table 2 presents the data numerically for nearness of pressure difference between the Pneuma-Tonometer and hydrogel lenses (Standard mean P_a-Lens mean P_1). In 56% of the eyes, the agreement was within ±1 mm. Hg; in 90% of eyes, the agreement was within ±2 mm. Hg; and in 95% of eyes the agreement was within ±3 mm. Hg.

Anesthetic and lens readings were plotted against each other with a 1:1 "perfect agreement" line drawn for comparison.

Part I.

Figure 4

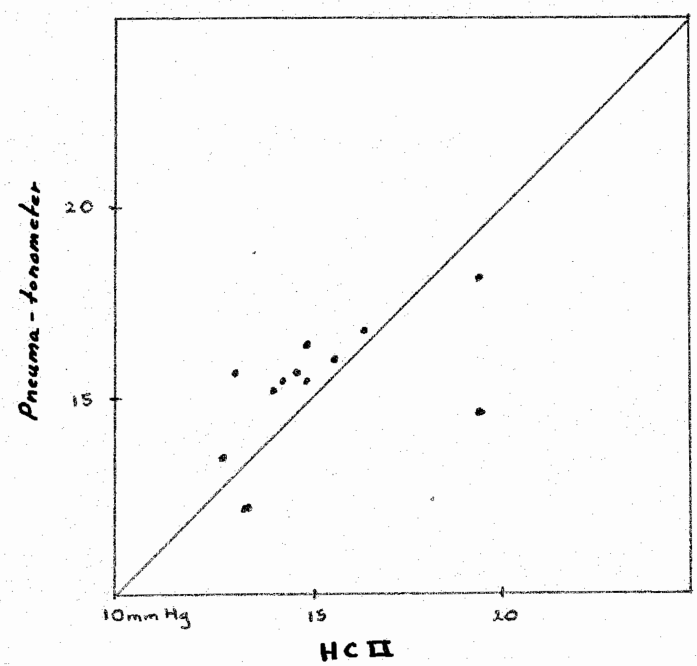


Figure 5

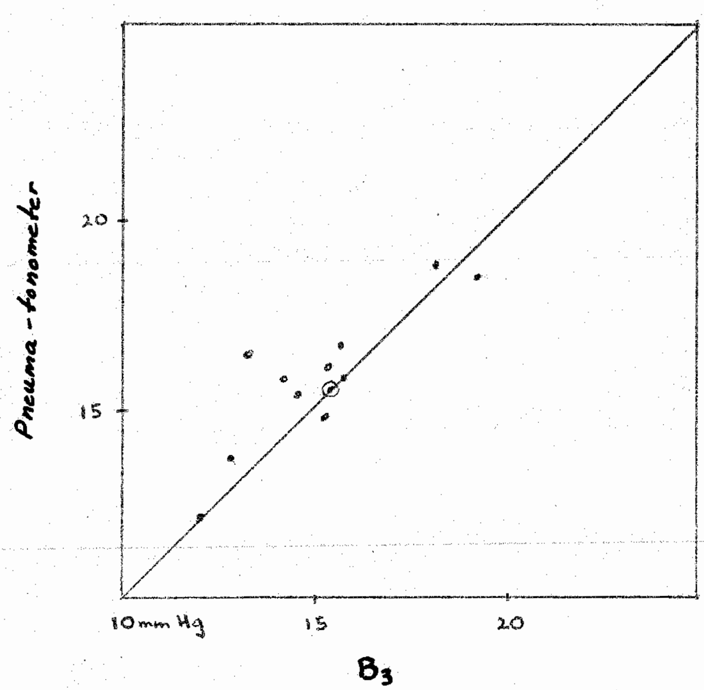


Figure 6

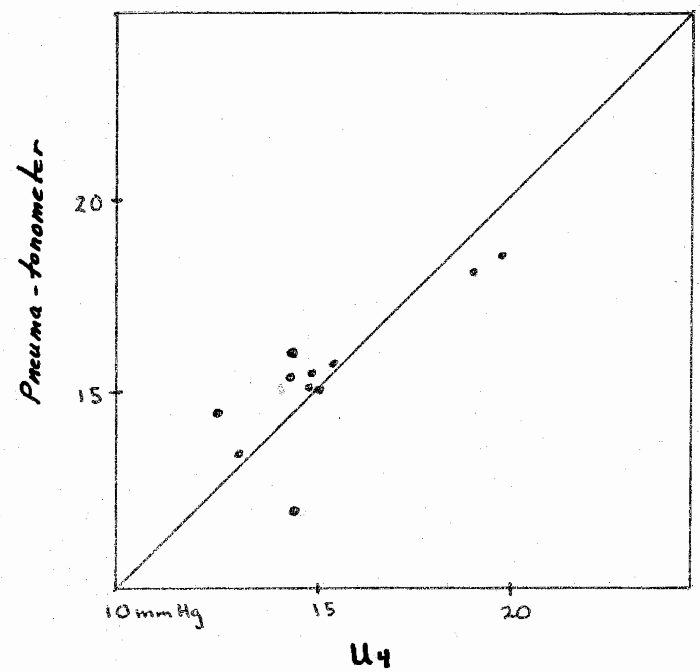


Figure 7

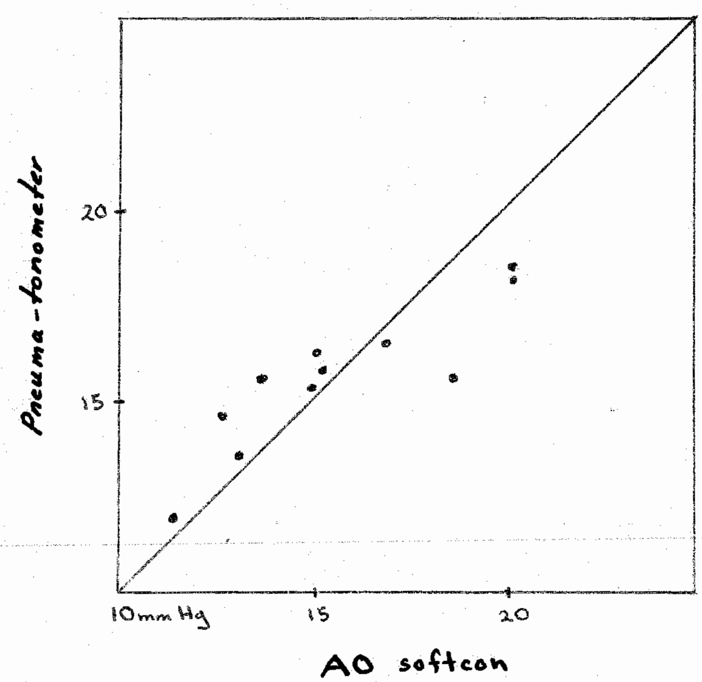


Figure 8

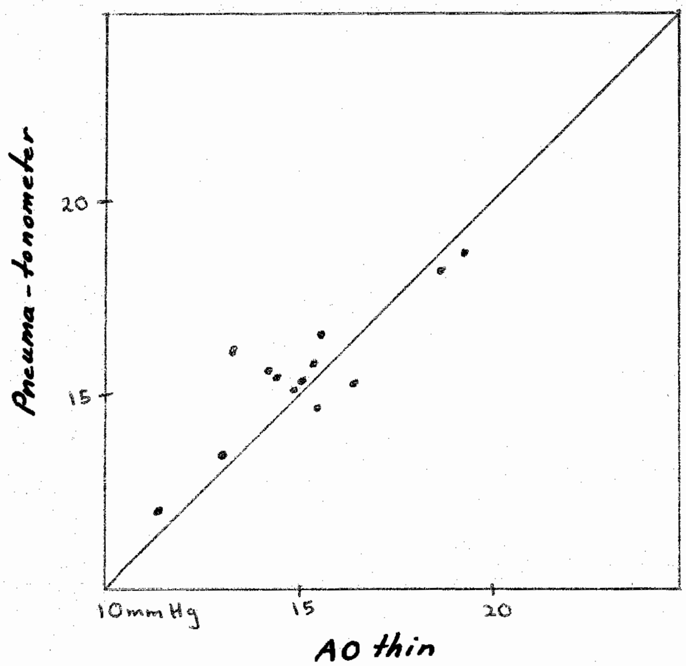
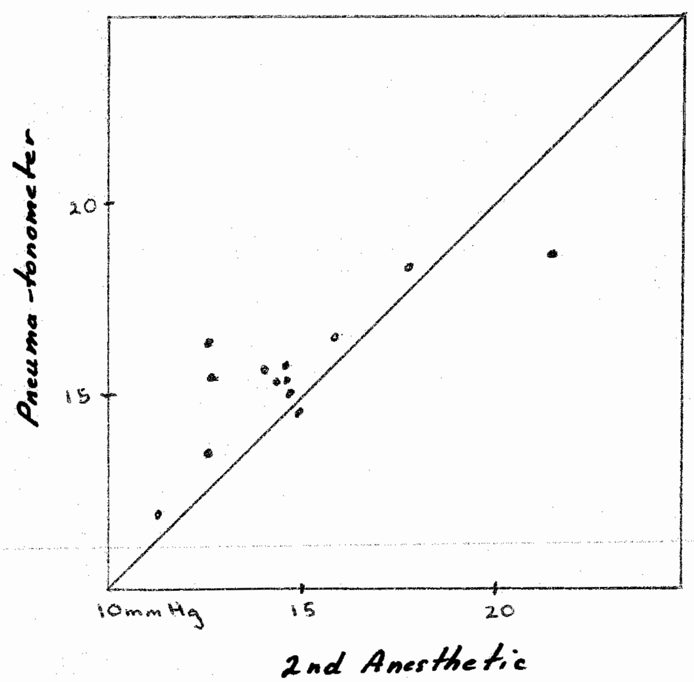


Figure 9



Please refer to Figures 4-9. For each of the six series the points fell more frequently above the 1:1 line indicating a tendency toward lower pressures both with lenses, and during the second anesthetic reading.

We observed of thirteen subjects, eight demonstrated lenses that moved and therefore made it difficult to obtain valid readings. The lenses that moved were the AO Softcon (four times), the AO Thin (three times), and the HCII (three times). On two subjects, both the AO Thin and the AO Softcon lenses moved. Since the AO Softcon moved four times we rejected its use in the latter portion of the study. Since the AO Thin and the HCII moved with equal frequency, we selected the HCII on the basis that it was easier for the examiners to handle.

Results--Part II.

The results of sensation of patients for the three series were compiled (refer to Table 4). Patients were asked to rate the sensation on a scale of one through seven; one causing the least sensation, seven causing the most sensation. The Mann-Whitney test, which decides whether two samples come from identical populations, was performed on the three series. Both the B3 and the Hydrocurve II were accepted as giving no different results than the anesthetic population. The U4 was rejected as being different from the anesthetic.

Part II.

Figure 10

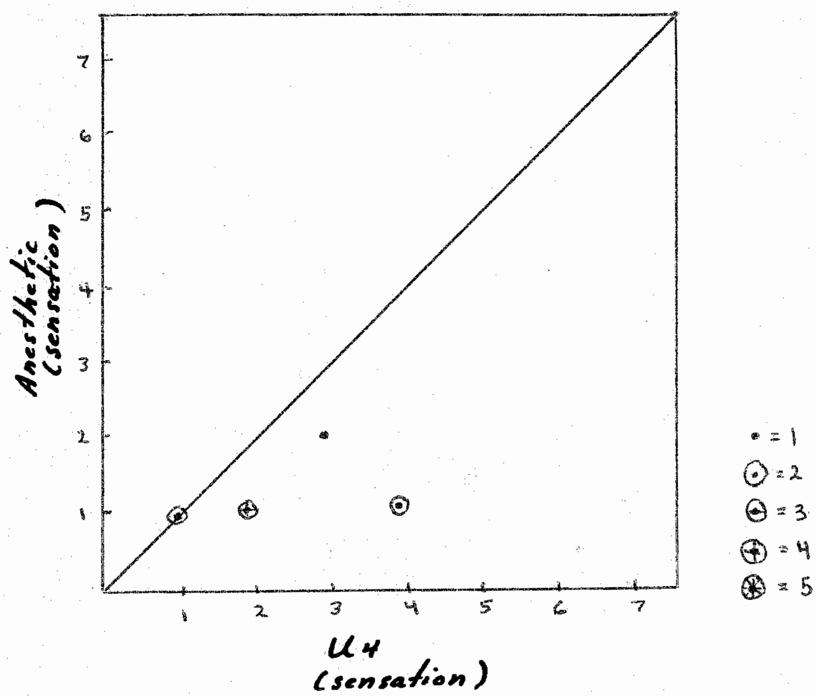


Figure 11

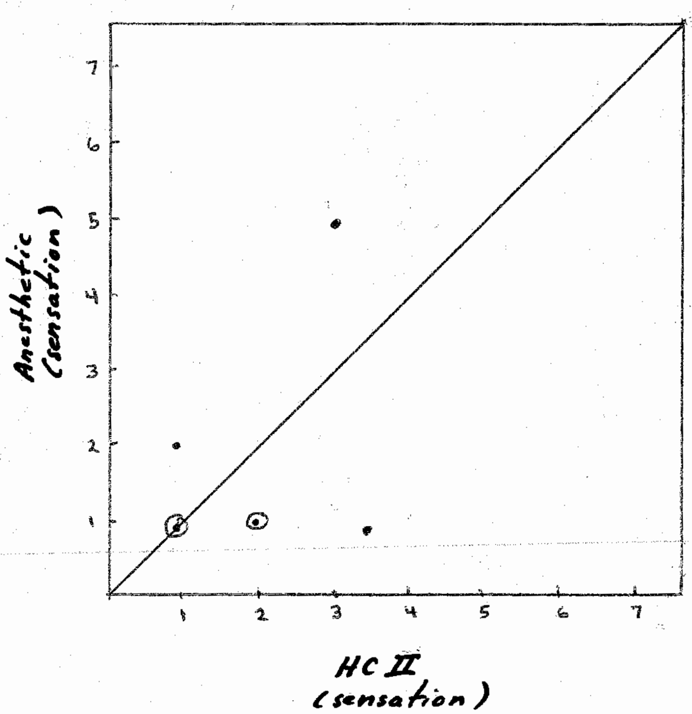


Figure 12

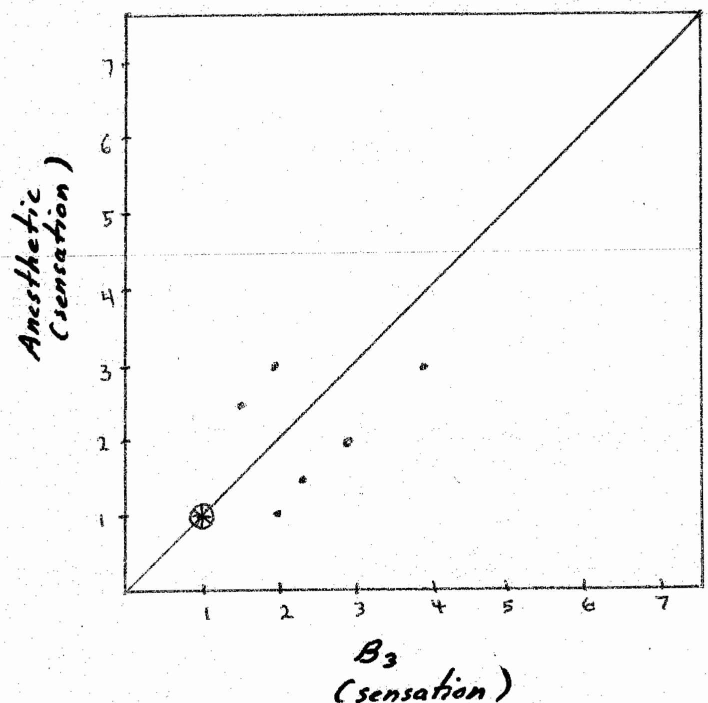


Figure 13

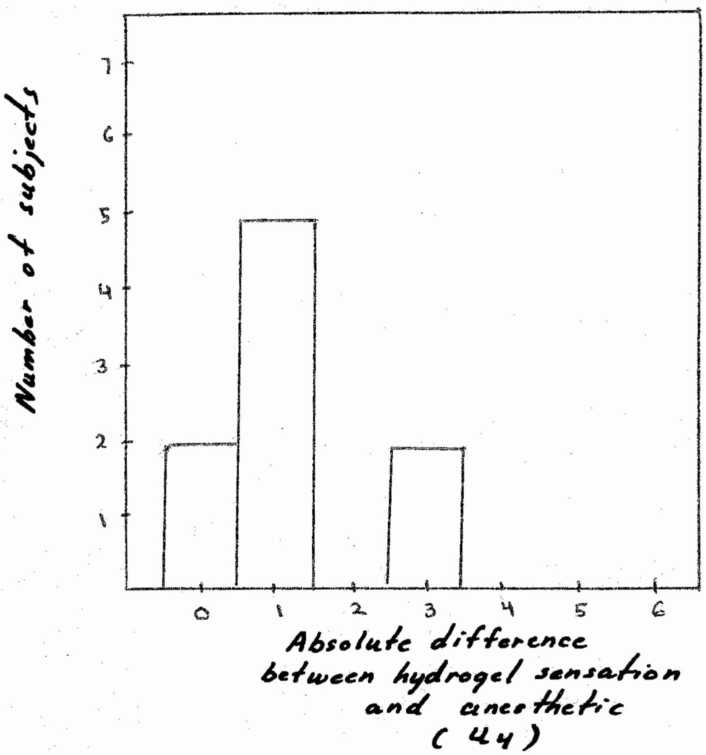


Figure 14

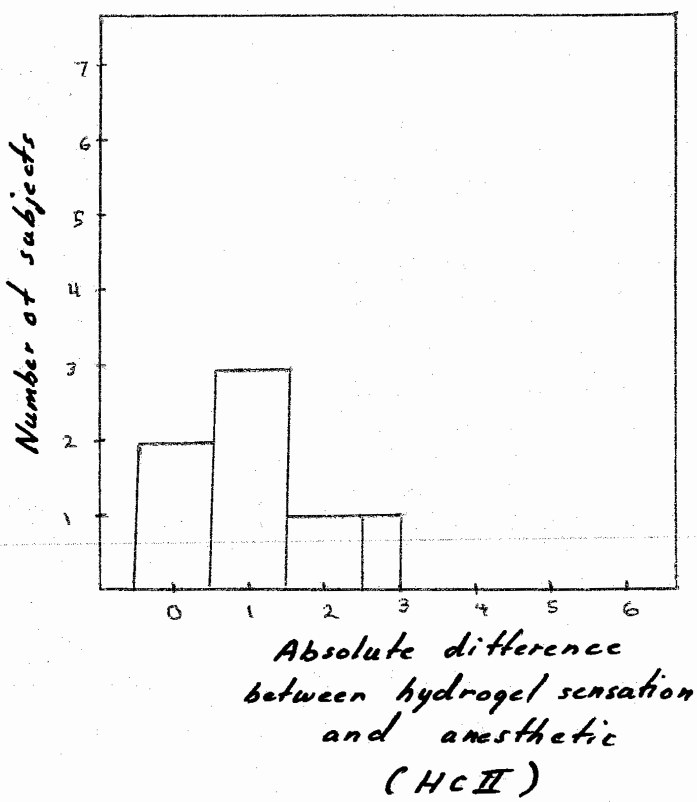
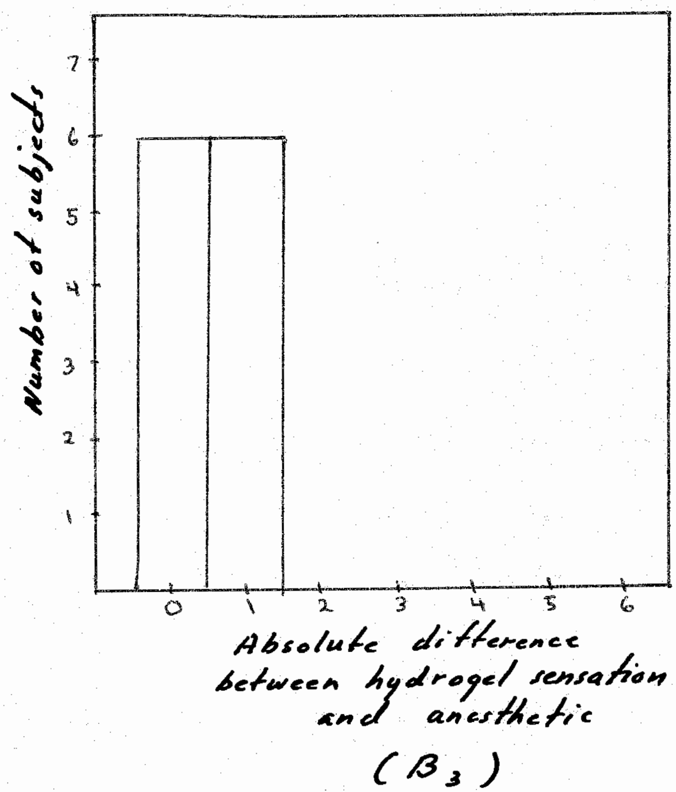
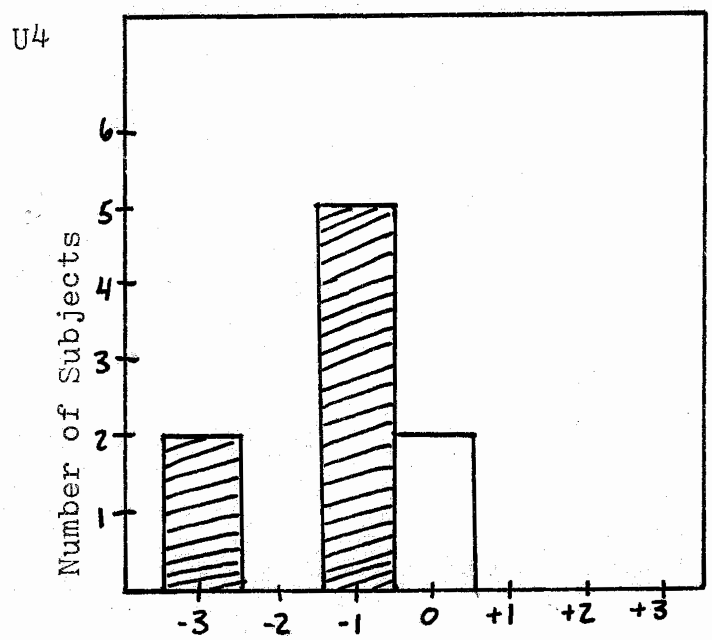


Figure 15



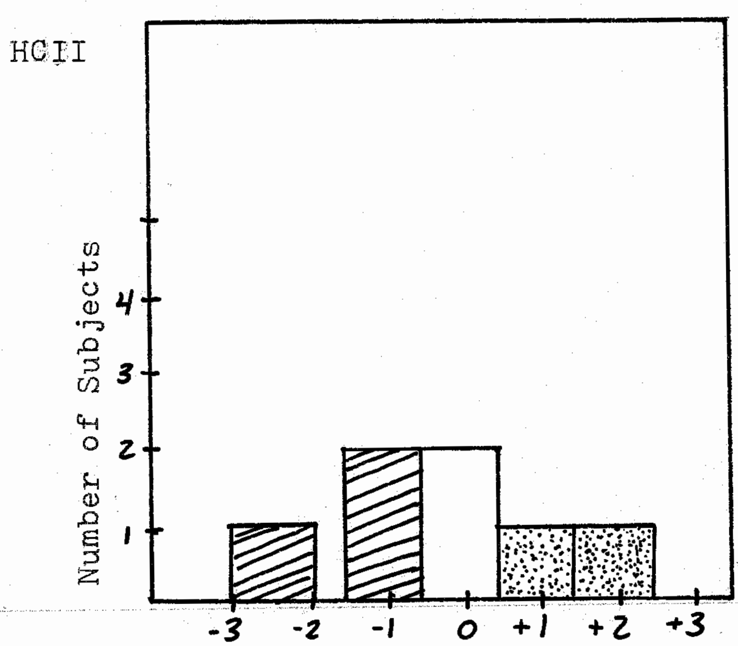
Number of subjects
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Absolute difference between hydrogel sensation and anesthetic
(B3)

Figure 16



(anesthetic sensation-contact lens sensation)
(-) being more sensation with contact lens
(+) being less sensation with contact lens

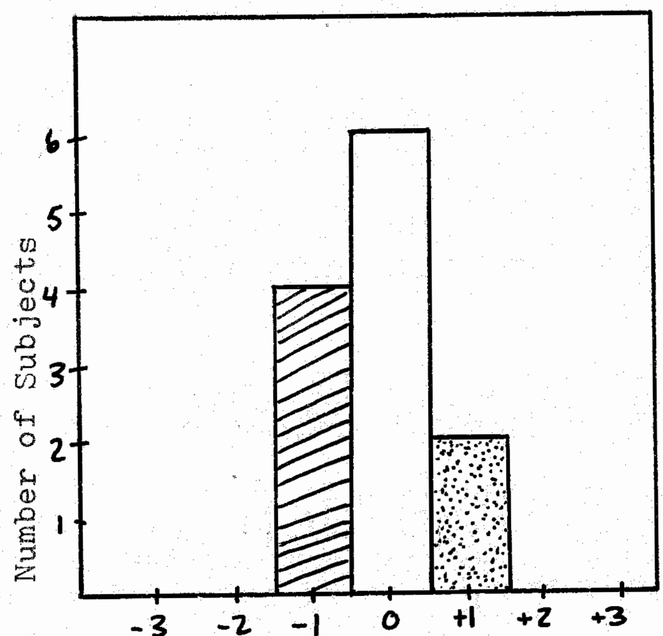
Figure 17



(anesthetic sensation-contact lens sensation)
(-) more sensation with contact lens
(+) more sensation with anesthetic
(0) no difference

Figure 18

B3



(anesthetic sensation-contact lens sensation)

(-) more sensation with contact lens
(+) more sensation with anesthetic
(0) no difference

Discussion

Pneuma-Tonometer readings through HCII, B3, U4, AO Softcon, and AO Thin are accurate for intraocular pressure measurements under controlled experimental conditions, according to the t-test. It is, however, evident that there is a great need in such work for strict control of methods and for cautious interpretation of results on living eyes. Many variables must be taken into account when trying to show that IOP does not vary under two separate conditions.

We do feel, however, that to the clinician, the proximity of mean pressures between readings with a lens and without anesthetic may be useful. Of the readings with soft lenses in place, 56% were within ±1mm. of the standard, 90% were within ±2mm. of the standard, and 95% were within ±3mm. Hg. The B3 and the Hydrocurve II lenses were accepted as being no different in sensation from the anesthetic population. However, our statistical Mann-Whitney U test does not say anything about which procedure was more comfortable. To make some statement about this, only trends can be reported. It is interesting to note that during testing with the B3 lenses, nine of the eleven subjects found the B3 lens to be more comfortable or equally comfortable during tonometry as the anesthetic. On the U4 and the HCII lenses, subjects seemed to rate the anesthetic as being more comfortable by a narrow margin. (Please refer to Tables 4 and 5 and Figures 10 through 18).

The consensus of the authors is that the Bausch and Lomb B3 handled easiest, fitted best, and was tolerated by the most people.

Although there is additional work involved in putting these lenses on, only one person out of twenty-nine was unable to have the lens placed on his/her eye. Eye make-up was a slight setback to the procedure-it contaminated some lenses.

Another observation noted was that corneas consistently demonstrated less abrasion/stippling effect with the soft lenses than with the anesthetic (see Table 4).

Conclusions

1. All the chosen lenses proved to give accurate readings for IOP with the Pneuma-Tonometer over a range of pressures 12.0-18.5mm. Hg.
2. 56% P_a-P_1=within $\pm$1 mm. Hg.
   90% P_a-P_1=within $\pm$2 mm. Hg.
   95% P_a-P_1=within $\pm$3 mm. Hg.
3. For Bausch and Lomb B3 lenses and Hydrocurve II lenses, no significant difference exists in patient sensation during tonometry through the lens versus tonometry with an anesthetic.
4. More corneal epithelial staining was observed after tonometry using the anesthetic than after tonometry using a soft lens.
5. Since our study population consisted of subjects with pressures limited to the normal range, we recommend that future researchers investigate subjects with "high-normal", "borderline", and glaucomatous intraocular pressures.

ENDNOTES

[1]William Thorburn, "The Accuracy of Clinical Applanation Tonometry," Acta Ophthalmologica, 58 (1978), p. 1.

[2]Irvin M. Borish, Clinical Refraction, 3rd ed. 2nd printing, (Chicago: Professional Press, Inc., 1975), p. 464.

[3]Robert A. Moses, editor, Adler's Physiology of the Eye: Clinical Application, 6th ed., (St. Louis: C.V. Mosby Co., 1975), p. 197.

[4]Harry A. Quigley and Maurice E. Langham, "Comparative Intraocular Pressure Measurements with the Pneumotonograph and the Goldmann Tonometer," American Journal of Ophthalmology, 80, No. 2, (August, 1975), p. 273.

[5]Sidney Wittenberg, "Evaluation of the Pneuma-Tonometer," American Journal of Optometry and Physiological Optics, 55, No. 5 (May, 1978), p. 346.

[6]op. cit., Quigley, p. 266.

[7]W.M. Lyle and C. Page, "Possible Adverse Effects From Local Anesthetics and the Treatment of These Reactions," American Journal of Optometry and Physiological Optics, 52 (November, 1975), p. 737.

[8]ibid., p. 737.

[9]Thomas J. Deluca, Lawrence S. Forgas, and Stanley D. Skolnick, "The Use of the Bausch and Lomb Soflens in Tonometry," Journal of American Optometric Association, 45, No. 9 (September, 1974), p. 1030.

[10]op. cit., Moses, p. 193.

[11]op. cit., Deluca, p. 1036.

[12]Kenneth Polse, Edward Haw, and Irving Fatt, "Measurement of Intraocular Pressure over a Gel Lens," American Journal of Optometry, 53, No. 1 (January, 1976), p. 5.

[13]G.K. Krieglstein, W.K. Waller, H. Reimers, and M.E. Langham, "Augeninnendruckmessung Auf Weichen Kontaktlinsen," Albrecht von Graefes Archives of Ophthalmology, 199, No. 3 (1976), p. 288.

[14]op. cit., Borish, p. 464.

[15]ibid., p. 464.

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