Comparative Study of the Effects of 2% Ibopamine, 10% Phenylephrine, and 1% Tropicamide on the Anterior Segment

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Purpose. To assess in normal and glaucomatous eyes the effect of the dopaminergic drug 2% ibopamine on visual acuity, IOP, pupil size and anterior segment geometry, compared with 10% phenylephrine and 1% tropicamide.

Methods. Fifteen healthy subjects and 15 patients with primary open-angle glaucoma, aged from 40 to 70 years (mean age: 54.8 ± 9.6), were recruited into this open prospective study. After instillation of 2% ibopamine, refraction, visual acuity, pupil diameter, IOP, five A-scan ultrasonographic parameters, and 15 ultrasound biomicroscopy parameters were evaluated. The study was repeated with assessment of the same parameters 20 to 30 days later in 10 subjects (5 normal and 5 with glaucoma), using first 10% phenylephrine and then 1% tropicamide. A second group of 15 healthy subjects, aged from 45 to 70 years (mean age: 53.5 ± 8.6) was examined to evaluate the dose–response effect and time course on pupil diameter, of ibopamine, phenylephrine, and tropicamide.

Results. After 40 minutes 2% ibopamine induced a marked mydriatic effect (from 5 to 9.1 mm; $P < 0.0001$) greater than that produced by 10% phenylephrine (from 4.7 to 7.9 mm; $P < 0.0001$) or 1% tropicamide (from 4.6 to 6.9 mm; $P < 0.0001$), with no changes in refraction or visual acuity. IOP was significantly increased only in patients with glaucoma after instillation of either 2% ibopamine (from 22.2 to 24.8 mm Hg; $P < 0.0001$) or 1% tropicamide (from 21.2 to 23.6 mm Hg; $P = 0.004$), whereas 10% phenylephrine induced no statistically significant changes. Ibopamine (2%) caused a significant increase in iris thickness with a reduction of the sulcus ciliaris and posterior chamber depth. The anterior chamber angle (ACA) showed a mean 5° widening with an increase in scleral–iris angle (SIA) and sclera–ciliary process angle. In 11 (37%) of 30 cases, separation of the pupil border and lens surface occurred, whereas contact was maintained only with the zonule in the other 19 (63%) of 30. The changes after 10% phenylephrine instillation were similar, although only the increase in iris thickness and SIA was statistically significant. Tropicamide (1%) induced a slight but significant increase in SIA.

Conclusions. The results confirm the potent mydriatic effect of 2% ibopamine, which is greater than that of either 10% phenylephrine or 1% tropicamide, as well as its ability to induce an increase in intraocular pressure when used in patients with glaucoma alone. These data support the hypothesis that the widening of the ACA induced by 2% ibopamine is due to posterior rotation of the iris plane and ciliary processes. These changes are quantitatively greater than those induced by 10% phenylephrine and 1% tropicamide and are related to the greater mydriatic effect of the drug. (*Invest Ophthalmol Vis Sci.* 2003;44:281–289) DOI:10.1167/iovs.02-0221

Ibopamine is a poorly selective dopaminergic drug that is active not only on DA 1 and DA 2 receptors, but also on $\alpha 1$, $\alpha 2$, $\beta 1$, and $\beta 2$ receptors.[1,2] Unlike more selective dopaminergic agents,[3,4] ibopamine does not have the ability to reduce intraocular pressure (IOP). On the contrary, it shows the capability of increasing IOP in glaucomatous but not in normal eyes.[5–7] This property has been ascribed to the increase in production of aqueous humor.[7] As a result of this characteristic, the drug has been proposed as a test substance for the diagnosis of initial forms of glaucoma.[6,7] On the same basis, its use may be advocated for the treatment of postoperative ocular hypotonia.

One effect of ibopamine particularly worthy of note is its ability to induce marked mydriasis, which is potentially useful for diagnostic purposes and presents the advantage of not being accompanied by accommodative paralysis. We analyzed the mydriasis produced by 2% ibopamine in a previous study,[8] in which the following points were confirmed. Ibopamine-induced mydriasis is very pronounced, is prevented by pretreatment with 0.5% dapiprazole, and is rapidly reversed when the latter drug is instilled with the mydriasis already present. It is not accompanied by any changes in refraction or anterior chamber depth or in lens position as evaluated by A-scan ultrasonography. All these findings suggests that the mydriatic effect is due to activation of α-adrenergic receptors. We also confirmed that a slight increase in IOP occurs in glaucomatous eyes, but not in normal eyes, after instillation of ibopamine.

The drug thus is very promising as a substance to be used for diagnostic mydriasis and offers the possibility of inducing risk-free, easily reversible mydriasis in conformity with the principle of safe mydriasis of Mapstone.[9] The effects of the drug on the anterior segment have been assessed in an ultrasound biomicroscopy study, which, apart from mydriasis, revealed no other changes of note in the anterior segment.[10]

In view of the possible diagnostic value of this drug, we thought it would be useful to compare its effects on the pupil and anterior segment with those of two commonly used mydriatic agents, phenylephrine and tropicamide.

We focused particularly on biometric parameters detectable with the aid of ultrasound biomicroscopy (UBM), to be able to determine and compare the effective validity of the substance as a diagnostic mydriatic agent and assess whether it provides the necessary safety profile.

Methods

A first cohort of 15 healthy subjects (7 men, 8 women), aged from 45 to 70 years (mean age: 53.5 ± 8.6) was enrolled to evaluate the dose–response effect on pupil diameter of ibopamine, phenylephrine,

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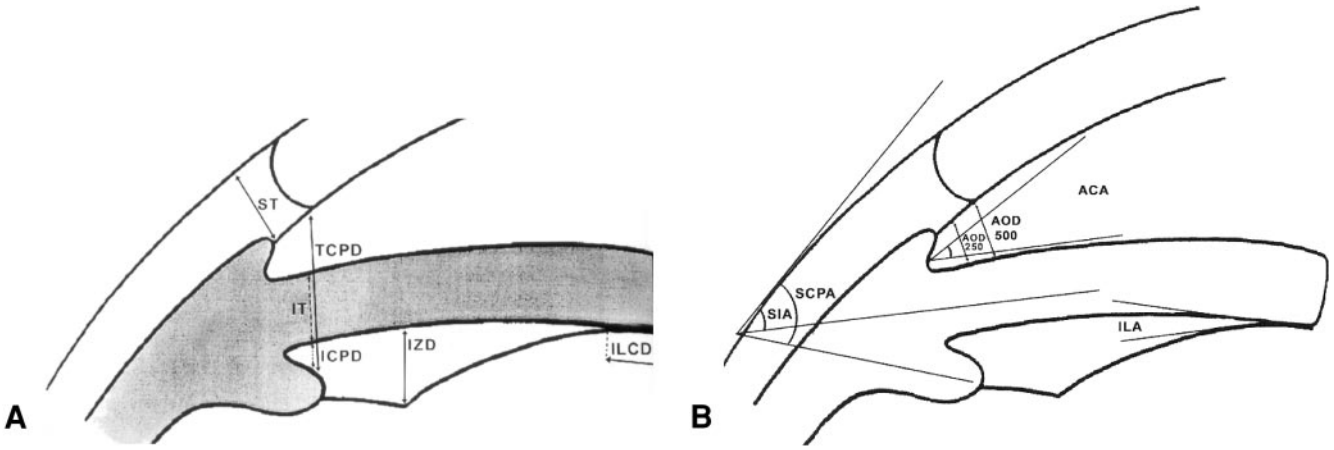

FIGURE 1. Linear (**A**) and angular (**B**) UBM parameters. ST, scleral thickness; TCPD, trabecular–ciliary process distance; IT, iris thickness; ICPD, iris–ciliary process distance (sulcus ciliaris); IZD, iris–zonule distance (posterior chamber depth); ILCD, iris–lens contact distance; ACA, anterior chamber angle; AOD 500, angle opening distance at 500 μm from the scleral spur; AOD 250, angle opening distance at 250 μm from the scleral spur; ILA, iris–lens angle; SIA, sclera–iris angle; SCPA, sclera–ciliary process angle.

and tropicamide. Using a computer-generated randomization list and sequential numbering, the subjects were randomly divided into three equal groups, each of them receiving one of the three drugs in different concentrations obtained by different ratios to the saline solution. Four dosages of ibopamine (0.25%, 0.5%, 1%, and 2%), three dosages of phenylephrine (2.5%, 5%, and 10%) and three dosages of tropicamide (0.25%, 0.5%, and 1%) were tested at different times in each of the three groups.

The five subjects in each group, received the allocated drug in only one eye randomly selected, whereas the fellow eye was treated with one drop of saline solution. Pupil diameter was measured in both eyes before treatment and at 30, 40, 60, and 90 minutes and 2, 4, and 8 hours after administration of the drugs.

A second cohort of thirty volunteers (9 men, 21 women), aged from 40 to 70 years (mean age: 54.8 ± 9.6), consisting of 15 healthy subjects and 15 patients with primary open-angle glaucoma (POAG), were recruited into the study. Subjects were patients with newly diagnosed POAG and were studied before medication had been prescribed that might affect IOP.

Informed consent was obtained from all subjects. The research was conducted in accordance with the principles laid down in the Declaration of Helsinki.

Pupil diameter was measured before treatment and 30, 40, 60, and 90 minutes and 2, 4, and 8 hours after administration of the drugs. In the second group, the study protocol, based on an open-label design, provided for the instillation of 1 drop of 2% ibopamine in only one eye chosen at random, with a second administration after 5 minutes. Two drops of saline solution were instilled into the fellow eye, according to the same procedure.

One hour before administration of the drug (baseline: time 0), each subject underwent determinations of refraction, visual acuity, pupil diameter, and IOP. Measurement of these parameters was repeated 30, 40, 60, and 90 minutes and 2, 4, and 8 hours after instillation of the drug. To reduce the likelihood of corneal abrasions, IOP was measured only after 40 and 120 minutes. A-scan ultrasonographic and UBM parameters were determined 30 minutes before and 40 minutes after administration of the eye drops.

In 10 of these subjects (five normal and five with glaucoma), the experiment was repeated 20 to 30 days later, according to the same procedure, first with 10% phenylephrine and then with 1% tropicamide. The time interval between the phenylephrine and tropicamide treatments was 10 to 12 days.

The following variables were assessed: subjective and objective refraction (using an AR-800 autorefractometer; Nidek Co., Gamagori, Japan); uncorrected and corrected visual acuity with a Monoyer decimal test card at the distance of 5 m; pupil diameter, according to the method of Bonora and Bonomi,[11] using a millimeter scale applied to the autorefractometer screen after focusing and in conditions of constant lighting; IOP measured by a Goldmann applanation tonometer after topical anesthesia with 0.4% benoxinate in a single-dose solution. The following A-scan ultrasonographic parameters were evaluated: anterior chamber depth, lens thickness, axial length, lens/axial length factor (LAF),[12] and relative lens position (RLP).[13] We adopted the standardized A-scan biometric immersion technique (Ophtascan S; Biophisic Médical, Clermont Ferrand, France) and a nonfocused 8-MHz transducer-probe with tissue sensitivity (*T*) of 68 dB. The techniques of examination and measurement have been reported in detail.[14]

UBM parameters, as defined by Pavlin et al.,[15] were also assessed: corneal thickness (CT), anterior chamber depth (ACD), with and without corneal thickness; anterior chamber angle (ACA); angle opening distance at 500 μm from the scleral spur (AOD 500); angle opening distance at 250 μm from the scleral spur (AOD 250); trabecular–ciliary process distance (TCPD), iris thickness (IT); iris–ciliary process distance (ICPD); iris–zonule distance (IZD); iris–lens contact distance (ILCD), sclera–ciliary process angle (SCPA); sclera–iris angle (SIA); scleral thickness (ST); and iris–lens angle (ILA; Figs. 1A, 1B). In addition to these parameters, contact, if any, between the pupil border and the lens or zonule, or the distance, if any, between these structures, was determined in mydriasis. The examinations were performed with a UBM instrument (model 840; Humphrey-Zeiss, San Leandro, CA) with a 50-MHz transducer probe allowing 5-mm tissue penetration and 50-μm resolution. The technique of examination and the reliability of UBM measurements have been reported in detail.[14]

The differences were tested by statistical analysis of variance using the one-way analysis-of-variance (ANOVA). UBM variables were analyzed by means of the Bonferroni multiple-comparison test.

RESULTS

Pupil Diameter

The results of the dose–response study are reported in Figs. 2A–C. Ibopamine (2%) induced a marked, statistically significant mydriatic effect ($P < 0.0001$) compared with 1%, 0.50%, and 0.25% concentrations. With phenylephrine, significant differences were observed only between the 2.5% and 5% concentrations at 30 ($P = 0.004$), 120 ($P = 0.036$), and 240 ($P = 0.022$) minutes. No significant differences among were observed 0.25%, 0.50% and 1% tropicamide.

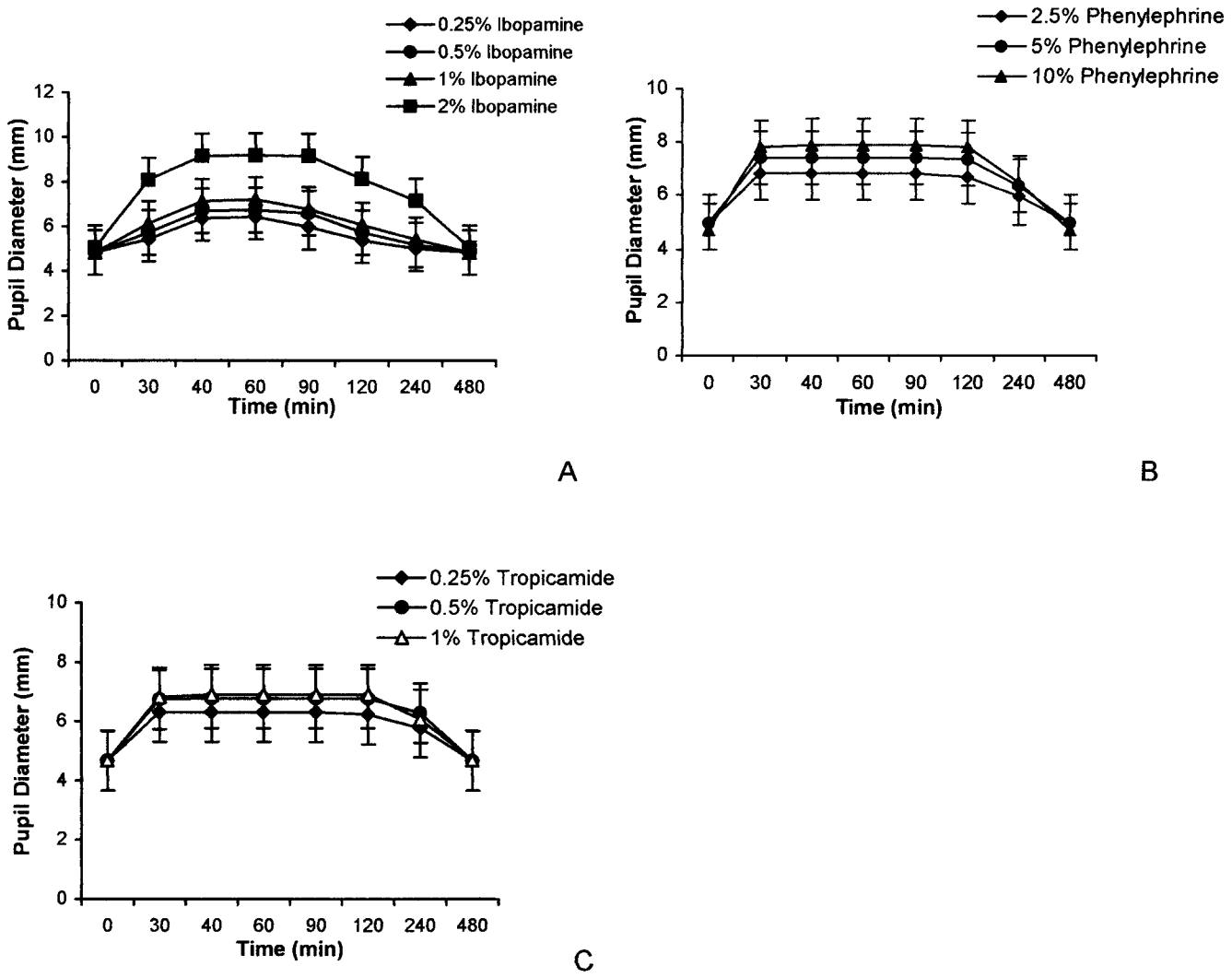

FIGURE 2. Dose–response and time course of the mydriatic effect of ibopamine (**A**), phenylephrine (**B**), and tropicamide (**C**).

Figure 3 illustrates the pupil diameter after instillation of 2% ibopamine, 10% phenylephrine, and 1% tropicamide, respectively. No significant differences emerged for any of the three drugs between patients with glaucoma and normal subjects with regard to their mydriatic effects. In healthy subjects and those with glaucoma taken as a whole, pupil diameters increased significantly compared with baseline (5.05 ± 0.59 mm for 2% ibopamine, 4.7 ± 0.75 mm for 10% phenylephrine, and 4.68 ± 0.84 mm for 1% tropicamide) as early as 30 minutes after instillation of the three drugs, with 2% ibopamine and 10% phenylephrine registering a more marked mydriatic effect (8.08 ± 0.57 and 7.80 ± 1.20 mm, respectively) than 1% tropicamide (6.81 ± 1.03 mm).

The maximum mydriatic effect of 1% tropicamide (6.90 ± 0.96 mm), 2% ibopamine (9.17 ± 0.50 mm), and 10% phenylephrine (7.90 ± 1.23 mm) was registered after 40 minutes. Pupil diameters then remained unchanged up to 90 minutes in the eyes treated with 2% ibopamine and up to 120 minutes in those treated with 1% tropicamide and 10% phenylephrine, with diameters returning to baseline after 480 minutes with all three drugs.

Intraocular Pressure

Compared with control eyes, a significant increase in IOP was detected only in patients with glaucoma both after instillation

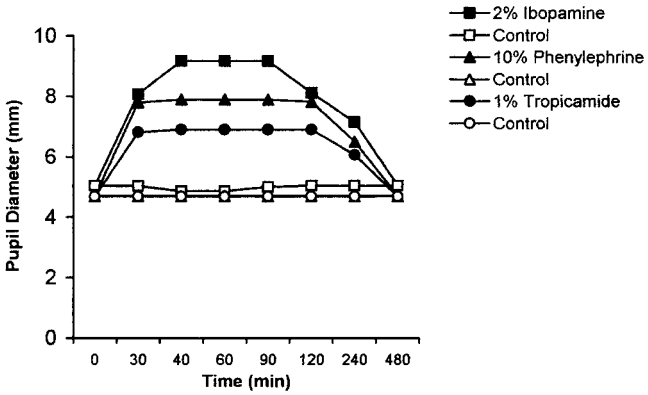

FIGURE 3. Effect of 2% ibopamine, 10% phenylephrine and 1% tropicamide on pupil diameter. One-way ANOVA test: treated versus control eyes: $P < 0.0001$ for all three drugs. For 2% ibopamine versus 10% phenylephrine: $P = 0.016$ at 40 minutes and $P = 0.015$ at 60 and 90 minutes; 2% ibopamine versus 1% tropicamide: $P = 0.005$ at 30 minutes, $P = 0.0001$ at 40, 60, and 90 minutes, $P = 0.022$ at 120 minutes, and $P = 0.028$ at 240 minutes. The differences between 10% phenylephrine and 1% tropicamide did not reach statistical significance. The differences between control eyes of the three groups were minimal and nonsignificant.

TABLE 1. Effects of 2% Ibopamine, 10% Phenylephrine and 1% Tropicamide on Intraocular Pressure

	Normal			POAG		
	Drug	Control	*P**	Drug	Control	*P**
Ibopamine 2%						
At baseline	14.8 ± 2.13	14.9 ± 2.40	NS	22.2 ± 1.74	21.7 ± 1.09	NS
After 40 min	14.5 ± 1.72	14.4 ± 2.19	NS	24.8 ± 1.37†	21.6 ± 1.29	<0.0001
After 120 min	13.8 ± 1.88	14.4 ± 1.72	NS	24.0 ± 1.51‡	20.6 ± 1.84	<0.0001
Phenylephrine 10%						
At baseline	14.8 ± 1.30	15.0 ± 1.73	NS	21.4 ± 1.34	21.2 ± 0.83	NS
After 40 min	14.2 ± 1.78	13.6 ± 1.78	NS	21.4 ± 1.14	21.4 ± 0.44	NS
After 120 min	14.0 ± 1.22	14.0 ± 1.00	NS	20.8 ± 0.44	21.0 ± 0.70	NS
Tropicamide 1%						
At baseline	15.3 ± 3.06	15.3 ± 3.06	NS	21.2 ± 1.10	20.8 ± 0.84	NS
After 40 min	14.6 ± 3.21	15.0 ± 2.65	NS	23.6 ± 1.14§	20.4 ± 1.34	0.004
After 120 min	15.0 ± 2.65	15.0 ± 3.61	NS	22.6 ± 0.55¶	20.4 ± 0.55	<0.0001

Data are expressed as mean IOP (mm Hg) ± SD. $n = 15$, ibopamine 2% and control groups; $n = 5$, phenylephrine 10%, tropicamide 1%, and control groups.

* Treated versus control eyes; one-way ANOVA.

† $P = 0.0001$ versus baseline.

‡ $P = 0.002$ versus baseline.

§ $P = 0.010$ versus baseline.

¶ $P = 0.034$ versus baseline.

of 2% ibopamine and after 1% tropicamide (Table 1). In patients with glaucoma, in the case of 2% ibopamine, the differences between treated and control eyes were 3.2 and 3.4 mm Hg after 40 and 120 minutes, respectively, whereas the corresponding differences after 1% tropicamide were 3.2 and 2.2 mm Hg. The differences in IOP both in patients with glaucoma and normal subjects in the group treated with 10% phenylephrine were not statistically significant.

Visual Acuity and Refraction

No statistically significant differences in uncorrected or corrected visual acuity or in refraction were found in any of the three treatment groups at any time during the observation period. Consequent to the overall lack of significance, data are not shown.

A-Scan Ultrasonographic Parameters

Table 2 gives details of the A-scan biometric parameter values after instillation of 2% ibopamine, 10% phenylephrine, and 1% tropicamide, respectively. No significant changes were observed after instillation of 2% ibopamine or 10% phenylephrine. In contrast, after instillation of 1% tropicamide there was a statistically significant 0.19-mm increase in anterior chamber depth ($P = 0.018$) and in relative lens position (0.05 increase; $P = 0.013$).

TABLE 2. Effects of 2% Ibopamine, 10% Phenylephrine, and 1% Tropicamide on A-Scan Parameters in Healthy and Glaucomatous Eyes

A-Scan Echographic Parameters	Drug			Control		
	Baseline	40 min Posttreatment	*P**	Baseline	40 min Posttreatment	*P**
Ibopamine 2%						
Anterior chamber (mm)	3.21 ± 0.34	3.26 ± 0.30	NS	3.23 ± 0.29	3.26 ± 0.32	NS
Lens (mm)	4.36 ± 0.42	4.30 ± 0.39	NS	4.38 ± 0.43	4.32 ± 0.40	NS
Axial length (mm)	23.0 ± 0.74	23.0 ± 0.79	NS	23.1 ± 0.87	23.1 ± 0.86	NS
Lens/axial length factor	1.88 ± 0.19	1.86 ± 0.18	NS	1.89 ± 0.18	1.86 ± 0.18	NS
Relative lens position	2.34 ± 0.10	2.34 ± 0.09	NS	2.33 ± 0.10	2.30 ± 0.19	NS
Phenylephrine 10%						
Anterior chamber (mm)	3.15 ± 0.24	3.28 ± 0.29	NS	3.12 ± 0.28	3.17 ± 0.25	NS
Lens (mm)	4.49 ± 0.47	4.50 ± 0.56	NS	4.45 ± 0.37	4.49 ± 0.37	NS
Axial length (mm)	23.1 ± 0.86	23.2 ± 0.96	NS	23.2 ± 1.18	23.3 ± 1.26	NS
Lens/axial length factor	1.93 ± 0.18	1.90 ± 0.20	NS	1.94 ± 0.17	1.92 ± 0.14	NS
Relative lens position	2.33 ± 0.08	2.36 ± 0.09	NS	2.31 ± 0.09	2.32 ± 0.10	NS
Tropicamide 1%						
Anterior chamber (mm)	3.17 ± 0.27	3.36 ± 0.24	0.018	3.15 ± 0.31	3.25 ± 0.28	NS
Lens (mm)	4.51 ± 0.53	4.40 ± 0.48	NS	4.55 ± 0.58	4.46 ± 0.44	NS
Axial length (mm)	23.3 ± 0.88	23.3 ± 0.96	NS	23.5 ± 1.21	23.5 ± 1.42	NS
Lens/axial length factor	1.93 ± 0.20	1.88 ± 0.19	NS	1.93 ± 0.19	1.89 ± 0.18	NS
Relative lens position	2.32 ± 0.09	2.37 ± 0.08	0.013	2.29 ± 0.12	2.32 ± 0.10	NS

Data are expressed as the mean ± SD.

* Treated versus control eyes; one-way ANOVA.

TABLE 3. A. Effects of 2% Ibopamine on UBM Parameters in Healthy and Glaucomatous Eyes

UBM PARAMETERS	2% Ibopamine (n = 15)		Control Eyes (n = 15)	
	Baseline	40 min Posttreatment	Baseline	40 min Posttreatment
Corneal thickness	0.598 ± 0.04	0.608 ± 0.04	0.592 ± 0.04	0.600 ± 0.04
Anterior chamber with corneal thickness	3.448 ± 0.29	3.489 ± 0.30	3.467 ± 0.30	3.480 ± 0.31
Anterior chamber without corneal thickness	2.938 ± 0.30	2.958 ± 0.30	2.940 ± 0.30	2.952 ± 0.31
Anterior chamber Angle	29.43 ± 7.81	34.37 ± 9.69	28.43 ± 10.1	28.73 ± 9.28
Angle opening distance at 500 μm	0.367 ± 0.15	0.416 ± 0.16	0.362 ± 0.14	0.364 ± 0.15
Angle opening distance at 250 μm	0.283 ± 0.13	0.305 ± 0.11	0.292 ± 0.13	0.281 ± 0.12
Trabecular–ciliary process distance	1.116 ± 0.27	1.126 ± 0.22	1.084 ± 0.23	1.099 ± 0.23
Iris thickness	0.403 ± 0.09	0.490 ± 0.10	0.380 ± 0.06	0.361 ± 0.08
Iris–ciliary process distance	0.384 ± 0.16	0.273 ± 0.12	0.385 ± 0.14	0.421 ± 0.14
Iris–zonule distance	0.669 ± 0.10	0.555 ± 0.12	0.665 ± 0.11	0.722 ± 0.09
Iris–lens contact distance	0.612 ± 0.23	None	0.647 ± 0.19	0.641 ± 0.17
Sclera–ciliary process angle	47.55 ± 6.88	50.10 ± 7.02	47.79 ± 6.95	46.36 ± 7.64
Sclera–iris angle	30.93 ± 7.06	39.24 ± 3.88	29.75 ± 4.76	30.45 ± 5.38
Sclera thickness	0.870 ± 0.06	0.885 ± 0.07	0.877 ± 0.05	0.874 ± 0.06
Iris–lens angle	19.45 ± 4.18	None	19.08 ± 3.82	18.52 ± 3.38

		Ibopamine Pre vs. Ibopamine Post	Ibopamine Pre vs. Control Pre	Ibopamine Pre vs. Control Post	Ibopamine Post vs. Control Pre	Ibopamine Post vs. Control Post	Control Pre vs. Control Post
Corneal thickness	Mean diff.	−0.010	0.006	−0.002	0.016	0.008	−0.008
	t	0.6840	0.4108	0.1369	1.095	0.5477	0.5477
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.04 to 0.02	−0.03 to 0.04	−0.04 to 0.03	−0.02 to 0.05	−0.03 to 0.04	−0.04 to 0.03
Anterior chamber with corneal thickness	Mean diff.	−0.041	−0.019	−0.032	0.022	0.009	−0.013
	t	0.3742	0.1734	0.2920	0.2008	0.082	0.1186
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.34 to 0.25	−0.31 to 0.28	−0.33 to 0.26	−0.27 to 0.32	−0.29 to 0.30	−0.31 to 0.28
Anterior chamber without corneal thickness	Mean diff.	−0.020	−0.002	−0.014	0.018	0.006	−0.012
	t	0.1810	0.01811	0.1267	0.1629	0.05431	0.1086
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.32 to 0.28	−0.30 to 0.30	−0.31 to 0.28	−0.28 to 0.32	−0.29 to 0.30	−0.31 to 0.29
Anterior chamber angle	Mean diff.	−4.940	1.000	0.700	5.940	5.640	−0.300
	t	1.461	0.2957	0.2070	1.757	1.668	0.08872
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−14.1 to 4.39	−8.24 to 10.2	−8.54 to 9.94	−3.30 to 15.1	−3.60 to 14.8	−9.54 to 8.94
Angle opening distance at 500 μm	Mean diff.	−0.049	0.005	0.003	0.054	0.052	−0.002
	t	0.8936	0.09119	0.0547	0.9848	0.9483	0.03647
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.19 to 0.10	−0.14 to 0.15	−0.14 to 0.15	−0.09 to 0.20	−0.09 to 0.20	−0.15 to 0.14
Angle opening distance at 250 μm	Mean diff.	−0.022	−0.009	0.002	0.013	0.024	0.011
	t	0.4587	0.1877	0.04170	0.2711	0.5004	0.2294
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.15 to 0.10	−0.14 to 0.12	−0.12 to 0.13	−0.11 to 0.14	−0.10 to 0.15	−0.12 to 0.14
Trabecular–ciliary process distance	Mean diff.	−0.010	0.032	0.017	0.042	0.027	−0.015
	t	0.1149	0.3678	0.1954	0.4827	0.3103	0.1724
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.24 to 0.22	−0.20 to 0.27	−0.22 to 0.25	−0.19 to 0.28	−0.21 to 0.26	−0.25 to 0.22
Iris thickness	Mean diff.	−0.087	0.023	0.042	0.110	0.129	0.019
	t	2.843	0.7515	1.372	3.594	4.215	0.6208
	P	**<0.05**	>0.05	>0.05	**<0.01**	**<0.001**	>0.05
	95% CI of diff.	−0.17 to 0.00	−0.06 to 0.10	−0.04 to 0.12	0.02 to 0.19	0.04 to 0.21	−0.06 to 0.10
Iris–ciliary process distance	Mean diff.	0.111	−0.001	−0.037	−0.112	−0.148	−0.036
	t	2.160	0.01946	0.7201	2.180	2.880	0.7006
	P	>0.05	>0.05	>0.05	>0.05	**<0.05**	>0.05
	95% CI of diff.	−0.02 to 0.25	−0.14 to 0.13	−0.17 to 0.10	−0.25 to 0.02	−0.28 to 0.00	−0.17 to 0.10
Iris–zonule distance	Mean diff.	0.114	0.004	−0.053	−0.110	−0.167	−0.057
	t	2.957	0.1037	1.375	2.853	4.331	1.478
	P	<0.05	>0.05	>0.05	**<0.05**	**<0.001**	>0.05
	95% CI of diff.	0.00 to 0.21	−0.10 to 0.10	−0.15 to 0.05	−0.21 to 0.00	−0.27 to 0.06	−0.16 to 0.04
Iris–lens contact distance	Mean diff.	0.612	−0.035	−0.029	−0.647	−0.641	0.006
	t	9.762	0.5583	0.4626	10.32	10.22	0.09571
	P	—	>0.05	>0.05	—	—	>0.05
	95% CI of diff.	0.44 to 0.78	−0.20 to 0.13	−0.20 to 0.14	−0.81 to 0.47	−0.81 to 0.46	−0.16 to 0.17
Sclera–ciliary process angle	Mean diff.	−2.550	−0.240	1.190	2.310	3.740	1.430
	t	0.9796	0.09220	0.4571	0.8874	1.437	0.5493
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−9.67 to 4.57	−7.36 to 6.88	−5.93 to 8.31	−4.81 to 9.43	−3.38 to 10.8	−5.69 to 8.55
Sclera–iris angle	Mean diff.	−8.310	1.180	0.480	9.490	8.790	−0.700
	t	4.217	0.5988	0.2436	4.816	4.461	0.3552
	P	**<0.001**	>0.05	>0.05	**<0.001**	**<0.001**	>0.05
	95% CI of diff.	−13.7 to 2.92	−4.21 to 6.57	−4.91 to 5.87	4.10 to 14.8	3.40 to 14.1	−6.09 to 4.69
Sclera thickness	Mean diff.	−0.015	−0.007	−0.004	0.008	0.011	0.003
	t	0.6799	0.3173	0.1813	0.3626	0.4986	0.1360
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.07 to 0.04	−0.06 to 0.05	−0.06 to 0.05	−0.05 to 0.06	−0.04 to 0.07	−0.05 to 0.06
Iris–lens angle	Mean diff.	19.45	0.370	0.930	−19.08	−18.52	0.560
	t	16.15	0.3073	0.7724	15.85	15.38	0.4651
	P	—	>0.05	>0.05	—	—	>0.05
	95% CI of diff.	16.1 to 22.7	−2.92 to 3.66	−2.36 to 4.22	−22.3 to 15.7	−21.8 to 15.2	−2.73 to 3.85

Probabilities are by Bonferroni multiple-comparison test. Pre, baseline; post, 40 min after treatment.

B. Effects of 2% Phenylephrine on UBM Parameters in Healthy and Glaucomatous Eyes

UBM PARAMETERS	10% Phenylephrine (n = 5)		Control eyes (n = 5)	
	Baseline	40 min Posttreatment	Baseline	40 min Posttreatment
Corneal thickness	0.588 ± 0.03	0.555 ± 0.04	0.595 ± 0.04	0.558 ± 0.04
Anterior chamber with corneal thickness	3.417 ± 0.30	3.422 ± 0.32	3.372 ± 0.30	3.359 ± 0.32
Anterior chamber without corneal thickness	2.891 ± 0.28	2.891 ± 0.31	2.835 ± 0.29	2.838 ± 0.32
Anterior chamber angle	31.20 ± 7.18	35.77 ± 9.71	29.77 ± 11.5	29.49 ± 6.25
Angle opening distance at 500 μm	0.390 ± 0.15	0.490 ± 0.23	0.353 ± 0.13	0.408 ± 0.12
Angle opening distance at 250 μm	0.301 ± 0.14	0.375 ± 0.19	0.283 ± 0.10	0.313 ± 0.10
Trabecular–ciliary process distance	1.144 ± 0.37	1.256 ± 0.22	1.069 ± 0.22	1.075 ± 0.19
Iris Thickness	0.395 ± 0.10	0.500 ± 0.10	0.348 ± 0.06	0.322 ± 0.06
Iris–ciliary process distance	0.392 ± 0.19	0.322 ± 0.16	0.390 ± 0.14	0.394 ± 0.12
Iris–zonule distance	0.613 ± 0.11	0.585 ± 0.17	0.671 ± 0.11	0.751 ± 0.12
Iris–lens contact distance	0.697 ± 0.35	None	0.703 ± 0.26	0.640 ± 0.12
Sclera–ciliary process angle	49.62 ± 8.35	51.64 ± 5.96	51.27 ± 6.08	46.60 ± 5.73
Sclera–iris angle	31.39 ± 6.62	39.26 ± 3.89	27.38 ± 4.68	29.71 ± 3.84
Sclera thickness	0.865 ± 0.05	0.866 ± 0.05	0.887 ± 0.05	0.887 ± 0.04
Iris–lens angle	17.71 ± 3.56	None	17.45 ± 3.61	17.67 ± 3.33

		Phenylephrine Pre vs. Phenylephrine Post	Phenylephrine Pre vs. Control Pre	Phenylephrine Pre vs. Control Post	Phenylephrine Post vs. Control Pre	Phenylephrine Post vs. Control Post	Control Pre vs. Control Post
Corneal thickness	Mean diff.	0.033	−0.007	0.030	−0.040	−0.003	0.0370
	t	1.748	0.3709	1.589	2.119	0.1589	1.960
	P	>0.05	>0.05	>0.05	**<0.05**	>0.05	>0.05
	95% CI of diff.	−0.02 to 0.08	−0.06 to 0.04	−0.02 to 0.08	−0.09 to 0.01	−0.05 to 0.05	−0.01 to 0.09
Anterior chamber with corneal thickness	Mean diff.	−0.005	0.045	0.058	0.050	0.063	0.013
	t	0.0322	0.2902	0.3740	0.3224	0.4062	0.08383
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.44 to 0.43	−0.39 to 0.48	−0.38 to 0.49	−0.39 to 0.49	−0.37 to 0.50	−0.42 to 0.45
Anterior chamber without corneal thickness	Mean diff.	0.000	0.056	0.053	0.056	0.053	−0.003
	t	0.0000	0.3728	0.3528	0.3728	0.3528	0.01997
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.42 to 0.42	−0.37 to 0.48	−0.37 to 0.47	−0.37 to 0.48	−0.37 to 0.47	−0.42 to 0.42
Anterior chamber angle	Mean diff.	−4.570	1.430	1.710	6.000	6.280	0.280
	t	1.026	0.3212	0.3841	1.348	1.411	0.06289
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−17.2 to 8.07	−11.2 to 14.0	−10.9 to 14.3	−6.64 to 18.6	−6.36 to 18.9	−12.3 to 12.9
Angle opening distance at 500 μm	Mean diff.	−0.100	0.037	−0.018	0.137	0.082	−0.055
	t	1.225	0.4531	0.2204	1.678	1.004	0.6735
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.33 to 0.13	−0.19 to 0.26	−0.24 to 0.21	−0.09 to 0.36	−0.14 to 0.31	−0.28 to 0.17
Angle Opening Distance at 250 μm	Mean diff.	−0.074	0.018	−0.012	0.092	0.062	−0.030
	t	1.076	0.2617	0.1745	1.338	0.9014	0.4361
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.26 to 0.12	−0.17 to 0.21	−0.20 to 0.18	−0.10 to 0.28	−0.13 to 0.25	−0.25 to 0.16
Trabecular–ciliary process distance	Mean diff.	−0.112	0.075	0.069	0.187	0.181	−0.006
	t	0.8625	0.5776	0.5314	1.440	1.394	0.04621
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.48 to 0.25	−0.29 to 0.44	−0.29 to 0.43	−0.18 to 0.55	−0.18 to 0.54	−0.37 to 0.36
Iris thickness	Mean diff.	−0.105	0.047	0.073	0.152	0.178	0.026
	t	2.547	1.140	1.771	3.687	4.317	0.6306
	P	>0.05	>0.05	>0.05	**<0.01**	**<0.01**	>0.05
	95% CI of diff.	−0.22 to 0.01	−0.07 to 0.16	−0.04 to 0.19	0.03 to 0.26	0.06 to 0.29	−0.09 to 0.14
Iris–ciliary process distance	Mean diff.	0.070	0.002	−0.002	−0.068	−0.0720	−0.004
	t	0.9051	0.02586	0.02586	0.8793	0.9310	0.05172
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.14 to 0.28	−0.21 to 0.22	−0.22 to 0.21	−0.28 to 0.15	−0.29 to 0.14	−0.22 to 0.21
Iris–zonule distance	Mean diff.	0.028	−0.058	−0.1380	−0.086	−0.166	−0.080
	t	0.4311	0.8930	2.125	1.324	2.556	1.232
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.15 to 0.21	−0.24 to 0.12	−0.32 to 0.04	−0.27 to 0.09	−0.35 to 0.01	−0.26 to 0.10
Iris–Lens contact distance	Mean diff.	0.697	−0.006	0.057	−0.703	−0.640	0.063
	t	6.165	0.05307	0.5042	6.218	5.661	0.5573
	P	—	>0.05	>0.05	—	—	>0.05
	95% CI of diff.	0.37 to 1.01	−0.32 to 0.31	−0.26 to 0.37	−1.02 to 0.38	−0.96 to 0.31	−0.25 to 0.38
Sclera–ciliary process angle	Mean diff.	−2.020	−1.650	3.020	0.370	5.040	4.670
	t	0.6107	0.4989	0.9130	0.1119	1.524	1.412
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−11.4 to 7.37	−11.0 to 7.74	−6.37 to 12.4	−9.02 to 9.76	−4.35 to 14.4	−4.72 to 14.0
Sclera–iris angle	Mean diff.	−7.870	4.010	1.680	11.88	9.550	−2.330
	t	3.220	1.640	0.6873	4.860	3.907	0.9532
	P	**<0.05**	>0.05	>0.05	**<0.001**	**<0.01**	>0.05
	95% CI of diff.	−14.8 to −0.93	−2.93 to 10.9	−5.26 to 8.62	4.94 to 18.8	2.61 to 16.4	−9.27 to 4.61
Sclera thickness	Mean diff.	−0.001	−0.022	−0.022	−0.021	−0.021	0.000
	t	0.04193	0.9225	0.9225	0.8806	0.8806	0.0000
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.06 to 0.06	−0.08 to 0.04	−0.08 to 0.04	−0.08 to 0.04	−0.08 to 0.04	−0.06 to 0.06
Iris–lens angle	Mean diff.	17.71	0.260	0.040	−17.45	−17.67	−0.220
	t	11.68	0.1715	0.02638	11.51	11.65	0.1451
	P	—	>0.05	>0.05	—	—	>0.05
	95% CI of diff.	13.4 to 22.0	−4.04 to 4.56	−4.26 to 4.34	−21.7 to 13.1	−21.9 to 13.3	−4.52 to 4.08

Probabilities are by Bonferroni multiple-comparison test. Pre, baseline; post, 40 min after treatment.

C. Effects of 1% Tropicamide on UBM Parameters in Healthy and Glaucomatous Eyes

UBM PARAMETERS	1% Tropicamide (n = 5)		Control Eyes (n = 5)	
	Baseline	40 min Posttreatment	Baseline	40 min Posttreatment
Corneal thickness	0.599 ± 0.03	0.573 ± 0.03	0.602 ± 0.05	0.564 ± 0.05
Anterior chamber with corneal thickness	3.486 ± 0.30	3.449 ± 0.31	3.440 ± 0.30	3.426 ± 0.31
Anterior chamber without corneal thickness	2.939 ± 0.35	2.899 ± 0.31	2.896 ± 0.29	2.882 ± 0.30
Anterior chamber angle	30.82 ± 7.79	35.70 ± 10.2	31.74 ± 12.0	30.86 ± 6.45
Angle opening distance at 500 μm	0.399 ± 0.17	0.500 ± 0.16	0.375 ± 0.13	0.417 ± 0.15
Angle opening distance at 250 μm	0.310 ± 0.16	0.381 ± 0.15	0.297 ± 0.10	0.322 ± 0.12
Trabecular—ciliary process distance	1.227 ± 0.37	1.353 ± 0.25	1.099 ± 0.23	1.209 ± 0.15
Iris thickness	0.418 ± 0.09	0.474 ± 0.12	0.356 ± 0.06	0.363 ± 0.11
Iris–ciliary process distance	0.446 ± 0.17	0.406 ± 0.15	0.409 ± 0.15	0.446 ± 0.05
Iris–zonule distance	0.659 ± 0.07	0.651 ± 0.12	0.691 ± 0.11	0.720 ± 0.09
Iris–Lens contact distance	0.609 ± 0.28	0.269 ± 0.16	0.643 ± 0.22	0.670 ± 0.20
Sclera–ciliary process angle	52.35 ± 6.79	51.38 ± 6.99	52.60 ± 4.96	51.12 ± 4.47
Sclera–iris angle	33.05 ± 6.26	38.48 ± 6.50	28.47 ± 4.37	30.06 ± 4.81
Sclera thickness	0.871 ± 0.05	0.882 ± 0.05	0.896 ± 0.06	0.902 ± 0.04
Iris–lens angle	18.95 ± 2.39	23.51 ± 6.05	17.65 ± 4.04	16.59 ± 3.02

		Tropicamide Pre vs. Tropicamide Post	Tropicamide Pre vs. Control Pre	Tropicamide Pre vs. Control Post	Tropicamide Post vs. Control Pre	Tropicamide Post vs. Control Post	Control Pre vs. Control Post
Corneal thickness	Mean diff.	0.026	−0.003	0.035	−0.029	0.009	0.038
	t	1.261	0.1455	1.698	1.407	0.4366	1.843
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.03 to 0.08	−0.06 to 0.05	−0.02 to 0.09	−0.08 to 0.02	−0.04 to 0.06	−0.02 to 0.09
Anterior chamber with corneal thickness	Mean diff.	0.037	0.046	0.060	0.009	0.023	0.014
	t	0.2426	0.3016	0.3934	0.05901	0.1508	0.0917
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.39 to 0.47	−0.38 to 0.47	−0.37 to 0.49	−0.42 to 0.44	−0.41 to 0.45	−0.41 to 0.44
Anterior chamber without corneal thickness	Mean diff.	0.040	0.043	0.057	0.003	0.017	0.014
	t	0.2553	0.2745	0.3638	0.01915	0.1085	0.08936
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.40 to 0.48	−0.40 to 0.48	−0.38 to 0.50	−0.44 to 0.44	−0.42 to 0.46	−0.43 to 0.45
Anterior chamber angle	Mean diff.	−4.880	−0.920	−0.040	3.960	4.840	0.880
	t	1.043	0.1966	0.008549	0.8463	1.034	0.1881
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−18.1 to 8.40	−14.2 to 12.3	−13.3 to 13.2	−9.32 to 17.2	−8.44 to 18.1	−12.4 to 14.1
Angle Opening Distance at 500 μm	Mean diff.	−0.101	0.024	−0.018	0.125	0.083	−0.042
	t	1.318	0.3133	0.2350	1.632	1.083	0.5482
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.31 to 0.11	−0.19 to 0.24	−0.23 to 0.19	−0.09 to 0.34	−0.134 to 0.300	−0.25 to 0.17
Angle opening distance at 250 μm	Mean diff.	−0.071	0.013	−0.012	0.084	0.059	−0.025
	t	1.055	0.1931	0.1783	1.248	0.8765	0.3714
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.26 to 0.12	−0.17 to 0.20	−0.20 to 0.17	−0.10 to 0.27	−0.13 to 0.25	−0.21 to 0.16
Trabecular–ciliary process distance	Mean diff.	−0.126	0.128	0.018	0.254	0.144	−0.110
	t	0.9614	0.9767	0.1373	1.938	1.099	0.8394
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.49 to 0.24	−0.24 to 0.50	−0.35 to 0.39	−0.11 to 0.62	−0.22 to 0.51	−0.48 to 0.26
Iris thickness	Mean diff.	−0.056	0.062	0.055	0.118	0.111	−0.007
	t	1.146	1.269	1.126	2.415	2.272	0.1433
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.19 to 0.08	−0.07 to 0.20	−0.08 to 0.19	−0.02 to 0.25	−0.02 to 0.24	−0.14 to 0.13
Iris–ciliary process distance	Mean diff.	0.040	0.037	0.000	−0.003	−0.040	−0.037
	t	0.5789	0.5354	0.0000	0.04341	0.5789	0.5354
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.15 to 0.23	−0.15 to 0.23	−0.19 to 0.19	−0.19 to 0.19	−0.23 to 0.15	−0.23 to 0.15
Iris–zonule distance	Mean diff.	0.008	−0.032	−0.061	−0.040	−0.069	−0.029
	t	0.1610	0.6440	1.228	0.8050	1.389	0.5837
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.13 to 0.14	−0.17 to 0.10	−0.20 to 0.08	−0.18 to 0.10	−0.21 to 0.07	−0.17 to 0.11
Iris–lens contact distance	Mean diff.	0.3400	−0.034	−0.061	−0.374	−0.401	−0.027
	t	3.101	0.3101	0.5563	3.411	3.657	0.2462
	P	**<0.05**	>0.05	>0.05	**<0.05**	**<0.01**	>0.05
	95% CI of diff.	0.02 to 0.65	−0.34 to 0.27	−0.37 to 0.25	−0.68 to 0.06	−0.71 to −0.08	−0.33 to 0.28
Sclera–ciliary process angle	Mean diff.	0.970	−0.250	1.230	−1.220	0.260	1.480
	t	0.3285	0.08465	0.4165	0.4131	0.08804	0.5011
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−7.41 to 9.35	−8.63 to 8.13	−7.15 to 9.61	−9.60 to 7.16	−8.12 to 8.64	−6.90 to 9.86
Sclera–iris angle	Mean diff.	−5.430	4.580	2.990	10.01	8.420	−1.590
	t	1.953	1.647	1.075	3.600	3.029	0.5719
	P	>0.05	>0.05	>0.05	<0.01	<0.05	>0.05
	95% CI of diff.	−13.3 to 2.46	−3.31 to 12.4	−4.90 to 10.6	2.11 to 17.9	0.52 to 16.3	−9.48 to 6.30
Sclera thickness	Mean diff.	−0.011	−0.025	−0.031	−0.014	−0.020	−0.006
	t	0.4357	0.9901	1.228	0.5545	0.7921	0.2376
	P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	95% CI of diff.	−0.08 to 0.06	−0.09 to 0.04	−0.10 to 0.04	−0.06 to 0.05	−0.09 to 0.05	−0.07 to 0.06
Iris–lens angle	Mean diff.	−4.560	1.300	2.300	5.860	6.860	1.000
	t	2.216	0.6317	1.118	2.848	3.334	0.4859
	P	>0.05	>0.05	>0.05	<0.05	<0.05	>0.05
	95% CI of diff.	−10.4 to 1.28	−4.54 to 7.14	−3.54 to 8.14	0.01 to 11.7	1.01 to 12.7	−4.84 to 6.84

Probabilities are by Bonferroni multiple comparison test. Pre, baseline; post, 40 min after treatment.

UBM Parameters

The effects of 2% ibopamine, 10% phenylephrine, and 1% tropicamide on UBM parameters are shown in Tables 3A–C.

Iris Thickness. Forty minutes after instillation of 2% ibopamine, a significant 87-μm increase in iris thickness was observed ($P < 0.05$). A 105-μm increase in thickness was recorded 40 minutes after instillation of 10% phenylephrine, and results were significant in comparison with the control eye ($P < 0.01$). A minor 56-μm increase in iris thickness was detected after instillation of 1% tropicamide but, in this case,

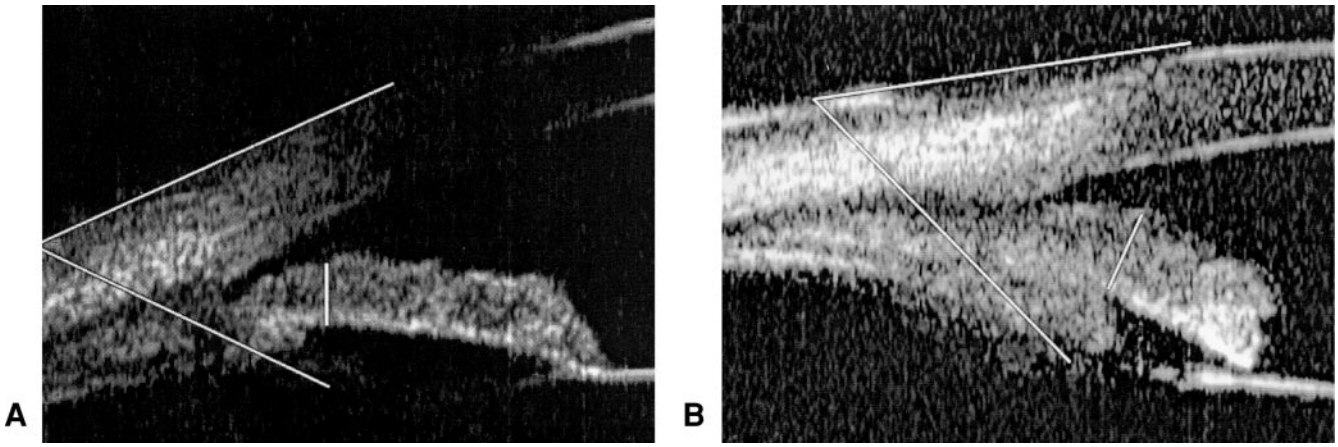

FIGURE 4. Iris thickness and sclera–ciliary process angle before (**A**) and after (**B**) treatment with 2% ibopamine.

the difference versus the thickness in control eyes was not significant (Fig. 4).

Iris–Ciliary Process Distance and Iris–Zonule Distance. In the eyes treated with 2% ibopamine, there was a significant 111-μm reduction in iris–ciliary process (sulcus ciliaris) distance ($P < 0.05$) and a 114-μm reduction in iris–zonule (posterior chamber) distance ($P < 0.05$). In the eyes treated with 10% phenylephrine and 1% tropicamide, statistically nonsignificant 70-μm and 40-μm reductions, respectively, were observed in the iris–ciliary process distance compared with the contralateral eyes. The mean reduction in iris–zonule distance with these two drugs was minimal and nonsignificant.

Anterior Chamber Angle. After instillation of 2% ibopamine, a 4.94° increase in anterior chamber angle occurred as well as a 49-μm increase in AOD 500, nevertheless statistically nonsignificant. Similarly, 10% phenylephrine and 1% tropicamide induced an increase of anterior chamber angle and angle opening at 500 and 250 μm from the scleral spur without statistical significance.

Sclera–Iris Angle and Sclera–Ciliary Process Angle. Significant increases in scleral–iris angle were observed after instillation of 2% ibopamine (8.31° [$P < 0.001$]), 10% phenylephrine (7.87° [$P < 0.05$]) and, in comparison with the contralateral eye, 1% tropicamide (8.42° [$P < 0.05$]). In the eyes treated with 2% ibopamine, a 2.55° increase in sclera–ciliary process angle was observed without statistically significant results (Fig. 4).

Relationship of Pupil Border to Zonule–Lens Structures. In 11 of 30 eyes treated with 2% ibopamine and in 3 of 10 treated with 10% phenylephrine, separation of the pupil border from the lens occurred after 40 minutes, measuring 238 ± 0.11 μm after 2% ibopamine and 231 ± 0.11 μm after 10% phenylephrine (Fig. 5A). In the remaining eyes, there was apposition of the pupil border to the zonule with the formation of a 208 ± 0.19-μm iris–zonule contact distance after instillation of 2% ibopamine and a 196 ± 0.14-μm contact distance after instillation of 10% phenylephrine (Fig. 5B). No detachment of the pupil border from the lens was observed in any of the eyes treated with 1% tropicamide, but only a significant 340-μm reduction of the iris–lens contact distance ($P < 0.05$; Fig. 5C). None of the changes observed in the other UBM parameters was statistically significant.

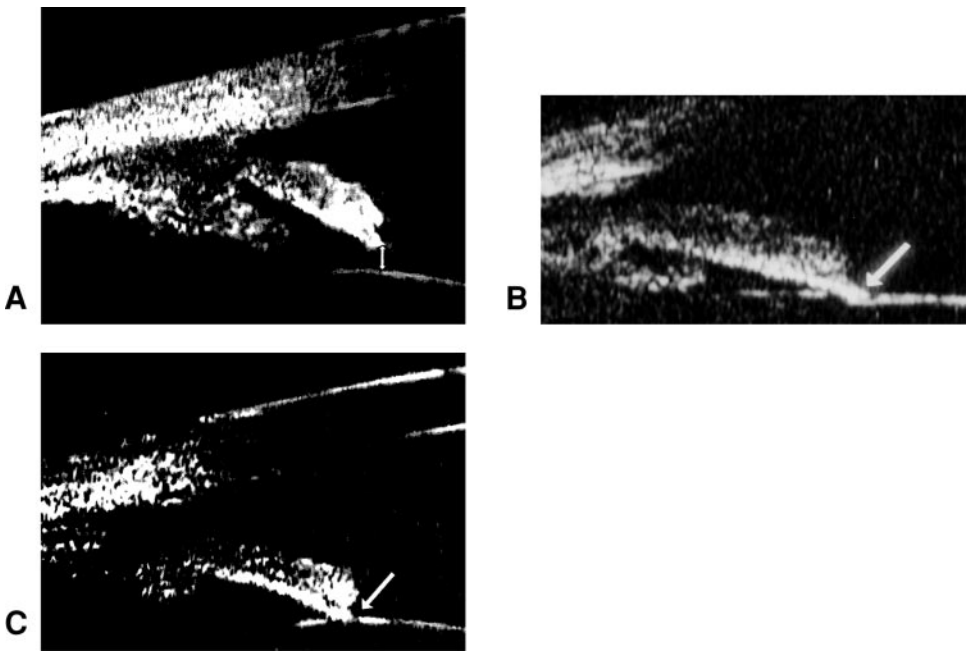

FIGURE 5. (**A**, **B**) mydriasis induced by 2% ibopamine. (**A**) Separation of the pupil border from the lens was visible (*double arrow*). (**B**) Formation of an iris–zonule contact was detectable (*arrow*). (**C**) Mydriasis induced by 1% tropicamide. Persistence of the iris–lens contact zone can be noted (*arrow*).

Discussion

Ibopamine exerted a particularly potent mydriatic effect. At the concentrations used, which are the ones currently available on the market, ibopamine produced a degree of mydriasis that was distinctly superior to that induced by phenylephrine and tropicamide, as shown by the dose–response study, with a duration of the mydriatic effects comparable to that of the other two drugs.

Our results confirm the IOP-increasing effect of ibopamine in patients with glaucoma alone, which Virno et al.[6] proposed as a diagnostic test in cases of suspected POAG. This effect is quantitatively too limited to contraindicate the use of the drug for diagnostic mydriasis. In this connection, it should be noted that the rapid and easy reversibility of ibopamine-induced mydriasis we reported in a previous study[8] constitutes a considerable advantage. These findings make 2% ibopamine an excellent candidate for a mydriatic agent for diagnostic purposes.

Unlike the findings of a recent report,[10] the mydriatic effect of 2% ibopamine was accompanied by a series of anatomicobiometric changes in the angle region and the retroiridial structures documented in vivo by UBM in our study. The dilatation of the pupil diameter induced by ibopamine (+82% compared with baseline values) was sufficient to cause detachment of the pupil border from the anterior surface of the lens in more than one third of cases, whereas in the other two thirds contact was maintained only with the zonule. The iris gathered in the angle and increased in thickness, thus causing a reduction in both iris–ciliary process distance (sulcus ciliaris) and iris–zonule distance (posterior chamber). The anterior chamber angle did not narrow as might be expected but widened, on average, by 5°. This slight, even if not significant, increase was confirmed by linear measurement of the angle opening at 500 μm from the scleral spur. The data in our possession are consistent with the hypothesis that the widening of the angle is the result of the posterior rotation of the iris plane and ciliary processes. Both these phenomena are documented and proved by the increases in the scleral–iris angle and scleral–ciliary process angle, respectively, even if the latter results were statistically nonsignificant.

All these changes also occurred after instillation of 10% phenylephrine, which induced a mydriatic effect (+68% compared with baseline pupil diameter) that was statistically less significant but similar to that of 2% ibopamine. In this case, however, only the changes in iris thickness and sclera–iris angle were statistically significant.

Tropicamide (1%), in contrast, had a less potent mydriatic effect (+47% compared with baseline values) and never produced separation of the pupil border from the lens surface. This drug, too, however, gave rise to a slight, though significant widening of the anterior chamber angle, as expressed by the sclera–iris angle.

The changes in the angle and iridociliary region induced by 2% ibopamine were of the same type as those induced by 10% phenylephrine and 1% tropicamide, although quantitatively greater. They are no cause for concern as regards the use of the drug and are related to its greater mydriatic effect.

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