Original Research Article

Assessment of pupil diameters in Pseudoexfoliation syndrome under scotopic, mesopic, photopic and dynamic conditions using infrared pupillometer

(Assessment of pupil diameters in Pseudoexfoliation syndrome)

Abstract

Aim: Our study aim to assess the pupil size under scotopic, mesopic, photopic and dynamic conditions in patients with PXS.

Methodology: This study was performed in Ophthalmology Clinic at İstanbul Bakırköy Dr.Sadi Konuk Training and Research Hospital. Fourty-six patients with PXS and 46 age and sex matched controls were included in the prospective study. The subjects were allowed at least 3 minute to adapt to the lighting condition in the room. Pupil diameters were measured with infrared (IR) pupillometer integrated within CSO Sirius Corneal Topographer (Costruzione Strumenti Oftalmici S.r.l,Italy) by same examiner. The measurements were used in scotopic, mesopic, photopic and dynamic condition. Statistical analyses were evaluated.

Results: Mean pupil diameter were significantly lower in the PXS group than control group for all measurements. Scotopic and mesopic pupil size were significantly lower in the PXS group than control group (p:0.0001). Also photopic and dinamic pupil size were significantly lower in the PXS group than control group (p:0.014, p:0.013).

Conclusion: The results suggest that pupillary light response in patients with PXS significantly was affected not only in scotopic and mesopic conditions both also in photopic and dynamic conditions.

Key Words: dynamic; mesopic; photopic; pseudoexfoliation syndrome; pupil size; scotopic.

INTRODUCTION

Pseudoexfoliation syndrome (PXS) is a genetically determined, age-dependent generalized disorder of the elastic fiber system, characterized by excessive production and accumulation of an elastotic material within a multitude of intra- and extraocular tissues [1]. PXS is diagnosed by visualising the pseudoexfoliative material on the pupillary ruff and/or on the anterior lens capsule. In ultrastructural studies, pseudoexfoliative material has been shown to be accumulated within conjunctiva, iris, ciliary epithelium, and the dilator muscle of fellow eyes in unilateral or asymmetric PXS [2,3]. Early stage of the disease may be recognized on the basis of the lens surface in addition to poor pupillary dilation and pigment-related signs including pigment dispersion and peripupillary atrophy [4].

Pupil size is influenced by many factors such as of the light stimulus and the stimulated eye, retinal illumination, accommodative state of the eye, sensory and emotional state, various neuro-psychiatric diseases, drugs, as well as the age and diabetes [5-8]. But studies about dynamic muscle function and pupil function with PXS are rare [9,10].

From this perspective, our study aim to assess the pupil size under scotopic, mesopic, photopic and dinamic conditions in patients with PXS.

MATERIAL AND METHODS

This prospective study was performed in Ophthalmology Clinic at İstanbul Bakırköy Dr.Sadi Konuk Training and Research Hospital. Fourty-six patients with PXS and 46 age and

sex matched controls were included in the study. The research followed the tenets of the Declaration of Helsinki, with local ethical commitee approval and the full informed consent of patients. All subjects underwent complete routine ophthalmological examination. The subjects with anterior segment and angle anomalies, diseases affecting the autoimmune system like diabetes, uveitis, pupil anomalies like posterior synechia, sleeplessness (including those with a history of partial sleeplessness) or with previous medical treatment like pilocarpin or other topical and oral medications that may affect autonomic function were excluded. The diagnosis of PXS were made by visualizing the pseudoexfoliative material on the pupillary ruff and/or on the anterior lens capsule. In the study were included same eyes of patients with unilateral PXS, right eyes of patients with bilateral PXS and right eyes of control groups. In control groups were not included unaffected eyes of patients with unilateral PXS from reasons such as pseudophakia, cataract, possible physiological anisocoria.

The subjects were allowed at least 3 minute to adapt to the lighting condition in the room. Pupil diameters were measured with infrared (IR) pupillometer integrated within CSO Sirius Corneal Topographer (Costruzione Strumenti Oftalmici S.r.l,Italy) by same examiner. The CSO Sirius Corneal Topographer consists a placido disc topographer, a 3 D rotating Scheimpflug camera, aberometer and integrated IR pupillometer. There were used binocular photomotor stimulus that both eyes perceive the same illumination. Also IR pupillometer have characteristics of dinamic pupillometry. The measurements were used in scotopic, mesopic, photopic and dynamic condition. ***Scotopic,*** in which the only visible light source is the LED source (0.4 lux). ***Mesopic*****,** in which the disk is illuminated in such a manner as to bring ambient light intensity to about 4 lux. ***Photopic***, in which disk is illuminated in such a manner as to bring ambient light intensity to about 40 lux. In another type of lighting condition, called ***Dynamic,*** capture is begun with the rings disk fully illuminated (500 lux ca.); it is switched off at the moment capture begins. In this manner, it is possible to monitor pupil dilation in

conditions from photopic to absence of light (scotopic conditions) and analyze pupil size and pupil offset instant by instant.

Statistical Analysis

Statistical calculations were performed with (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) program for Windows. Besides standard descriptive statistical calculations (mean and standard deviation), unpaired t test was used in the comparison of groups and Chi square test was performed during the evaluation qualitative data. *Pearson Correlation test used* to study the relationship between the variables. Statistical significance level was established at $p<0,05$.

RESULTS

In this study, there were included fourty-six patients with PXS and 46 sex, age-matched control subjects. There were no statistically significant differences in age and sex. The demographic data are listed in Table 1.

Pupil diameter in scotopic condition were measured between 2.65mm and 5.56 mm in PXS group, 3.65mm and 6.52mm in control group. It was mesured in mesopic condition between 2.43mm and 5.35mm; 2.93mm and 6.44mm, in photopic condition between 2.09mm and 4.99mm; 2.47mm and 5.74mm and dynamic pupil diameter between 2.3mm and 4.67; 2.49mm and 5.07mm respectively. Mean pupil diameters were significantly lower in the PXS group than control group for all measurements. Scotopic and mesopic pupil size were significantly lower in the PXS group than control group (p:0.0001). Also photopic and dinamic pupil size were significantly lower in the PXS group than control group (p:0.014,

p:0.013). Pupil size under scotopic, mesopic, photopic and dynamic conditions are listed in Table 2.

Correlation analysis revealed strong correlation in scotopic, mesopic, photopic and dynamic conditions both PXS and control groups (Table 3).

DISCUSSION

Pupil size is influenced by many factors such as illumination conditions, age, microvascular diseases like as diabetes mellitus, accomodation, fatigue, sensory and emotional status, and various drugs. Traditionally, pupil size has been evaluated with static pupillometers [11]. The recent technological developments in pupillometers, particularly incorporation of IR systems provide standardized intensity and duration of test light exposed, non-invazive, easy applicable, low inter-observer and intraobserver changes [12-14] . In our study, pupil size was measured with IR pupillometer integrated within CSO Sirius Corneal Topographer. Characteristics of this pupillometer include binocularity, objectivity, standardized illumination and dynamic pupil function.

A great many of articles compared various pupillometers using different techniques and devices [12,14-25]. The digital pupillometers allow examination of the dynamic pupil function in addition to scotopic, mesopic and photopic measurements of pupil size and provide objective data using a computer software. In these devices, intensities of test illumination are well-defined. IR pupillometers are able to take monocular or binocular mesurements. The fellow eyes taken with monocular pupillometer are affected due to fluctuations in room illumination. In contrary, measurements taken with binocular pupillometer can be advantageous because of more likely real-life conditions simulated [19,26].

All types of devices have been proved to give objective, standardized, reliable and repeatable data [14-16,19,22-25,27-31]. Schallenberg et al. compared Colvard, Procyon, and Neuroptics pupillometers for measuring pupil diameter under low ambient illumination. They indicate that monocular pupillometry either with the Neuroptics or Colvard pupillometer is at least as accurate as using the Procyon [14]. This result agrees with the studies of Kohnen et al. and Michel et al. [16,32]. Kohnen et al. stated that hand-held IR pupillometers with their simpler designs and portable features can also track the dynamic pupil process in an experienced hand. Furthermore, they concluded that the digital IR device shows less variation in scotopic pupil diameter and has better interrater repeatability than the hand-held IR devices [16]. Bootsma et al. noticed that digital binocular IR pupillometry is superior for obtaining standardized measurements of pupil size, because it approximates real-life conditions much more [19]. Some features of Procyon and Sirius IR pupillometer are similar in terms of binocularity, objectivity, standardization of illumination and dynamic measuring [21]. Altan et al. concluded that the tendency of smaller pupil size measurements with the Ocular Wavefront Analyzer might be due to the slightly higher ambiance illumination or an effect of accomodative miosis when subjects fixated on the a red light-emitting diode target in this device. Also emphasize that the larger pupil diameter found with the Sirius than with the Ocular Wavefront Analyzer and NeurOptics pupillometers may represent the different illumination levels used with each instrument together with relaxation of accommodation due to target fogging and software interpretation. They reported that different measurements are related not only to illumination and accommodation but also measurement algoritms or technique differences of instruments [25]. In our study were used binocular IR pupillometry.

It is known that mydriasis in eyes with PXS is restricted [2-4]. We did not find studies investigating pupil measurements using IR pupillometer. Yulek et al. were used videonystagmography in asymmetric pseudoexfoliation patients. They were measured the

percent of change in pupillary diameter in one second during the change in pupillary diameter during fixation to an accomodative target at 30 cm that is the accomodative response, during the light reaction, during the convergence-induced miosis, and finally during the divergence-induced mydriasis, both at fixed speed. They were declare that the difference between control group and pseudoexfoliative eyes of patient with PXS; between unaffected eyes and pseudoexfoliative eyes of patient with PXS was significant [10]. But they were unable to take measurements in different illumination conditions. Moreover, lack of normative data for responses of pupil to different illumination conditions can be interpreted as a limiting factor. Our study stands out with more numerous patients enrolled and a device with nomogram. It has shown significant variations in patients with PXS for 3 different light intensities and dynamic response. However it was influenced dilation more than miosis.

This is the first study evaluating the pupil measurements of patients with PXS using IR pupillometer integrated within CSO Sirius Corneal Topographer, since the Pub-Med search and other literature searches did not reveal any other similar paper.

In our study, the eyes of PXS were found to have smaller pupil diameters than control groups. The results suggest that pupillary light response in patients with PXS significantly deteriorate not only in scotopic and mesopic conditions but in photopic and dynamic conditions as well. According to our findings pseudoexfoliation material seem to affect dilator muscles profoundly than the sphincter muscles. Recently, cataract surgery is refractive surgery at the same time and visual expectations of individuals are extremely high. Physicians should choose the multifocal IOL that best suits individual patients' desired outcomes, increasing patients' visual outcomes and satisfaction. Therefore, we highlight that pupil size assessments under variable illumination conditions could be useful along with careful preoperative evaluation, particularly for patients with PXS who need better intermediate vision and refractive multifocal IOL.

CONCLUSION

The results suggest that pupillary light response in patients with PXS significantly was affected not only in scotopic and mesopic conditions both also in photopic and dynamic conditions. As Schlötzer-Schrehardt et al. say: "The Puzzle Continues"[1]. Does the smaller pupil size provide a decrease in mean correction in patients with PXS? Are the abberations of eyes less in PXS patients? How much does PXS affect the pupil velocity? We will continue to look for answers to these questions.

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Table 1.Demographic data of pseudoexfoliation syndrome and control group

		Pseudoexfoliation syndrome group		Control group		P
Age		73.5±6.57		73.43±6.92		0.963
Sex	**Female**	22	47.83%	20	43.48%	0.675
	Male	24	52.17%	26	56.52%	

Table 2. Pupil size under scotopic, mesopic, photopic and dynamic conditions

Mean Pupil Diameter	Pseudoexfoliaton Syndrome group	Control group	P
Scotopic	4.16±0.65	4.77±0.66	**0.0001**
Mesopic	3.85±0.67	4.56±0.68	**0.0001**
Photopic	3.28±0.66	3.64±0.72	**0.014**
Dynamic	3.14±0.56	3.42±0.5	**0.013**

Table 3. Results of the correlation analysis of pupil diameters in scotopic, mesopic, photopic and dynamic conditions of both groups

Pseudoexfoliation Group		Scotopic	Mesopic	Photopic	Dynamic
Scotopic	r		0.882	0.837	0.76
	p		0.0001	0.0001	0.0001
Mesopic	r	0.882		0.85	0.812
	p	0.0001		0.0001	0.0001
Photopic	r	0.837	0.85		0.905
	p	0.0001	0.0001		0.0001
Dynamic	r	0.76	0.812	0.905	
	p	0.0001	0.0001	0.0001	

Control Group		Scotopic	Mesopic	Photopic	Dynamic
Scotopic	r		0.962	0.716	0.724
	p		0.0001	0.0001	0.0001
Mesopic	r	0.962		0.792	0.781
	p	0.0001		0.0001	0.0001
Photopic	r	0.716	0.792		0.849
	p	0.0001	0.0001		0.0001
Dynamic	r	0.724	0.781	0.849	
	p	0.0001	0.0001	0.0001	