Impact of Valsalva Maneuver on Central Corneal Thickness, Anterior Chamber, Macular, Optic Nerve Parameters and Choroidal Thickness in Pseudoexfoliation Glaucoma Patients

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ABSTRACT

Purpose: To evaluate impact of Valsalva maneuver on central corneal thickness, anterior chamber parameters, optic nerve parameters and macular-choroidal thickness of pseudoexfoliation glaucoma (PEG) patients.

Materials and Methods: Fifty-three eyes of 30 patients with PEG were included in this study between January 2017 and August 2017. All patients under went optic disc, retinal nerve fiber layer (OD RNFL), central macular thickness (CMT) and subfoveal choroidal thickness (CT) measurements performed by Spectral Domain Optic CoherenceTomography (SD-OCT); irido corneal angle (ICA), anterior chamber depth (ACD), and central corneal thickness (CCT) measurements were performed with Sirius Scheimpflug-Placido Topographer before and during Valsalva maneuver (VM).

Results: OD RNFL parameters were significantly decreased during the VM (82.1±21.5 µm before VM, 81.6±21.2 µm during VM, p‹0.034). There were decrease in parameters of CMT (218.9±25 µm before VM, 217.5±24 µm during VM p=0.83), ICA (42.5°±9 before VM, 42.0°±9 during VM , p=0.188) and ACD (3.39±0.6 mm before VM, 3.38±0.6 mm during VM , p=0.082) but these impacts were not significant. There was significantly increase in parameters of subfoveal CT during VM (213.3±40.9 µm before and 224.0±40.0 µm during VM; p‹0.001). There was increase in parameters of CCT but this impactwas not significant (536.2±33.5 µm before VM , 537.5±35.8 µm during VM , p=0.237).

Conclusions: The VM has some influence on corneal morphology and anterior chamber parameters, but they were not significant. The changes in RNFL and CT have to be in mind during patient examination due to thein fluence of VM.

Keywords: Pseudoexfoliation, Glaucoma, Valsalva, Choroid, Cornea.

INTRODUCTION

Pseudoexfoliation syndrome (PEX) is a kind of unique age-related fibrillopathy characterized by deposition of dandruff-like material over ocular tissues like cornea, anterior chamber, posterior ciliary artery, vortex veins and various organs of the body like skin, lungs, heart, kidney and meninges.[1-3] Approximately 20% of patients with newly diagnosed PEX have either glaucoma (PEG) or increased intraocular pressure (IOP). Of the patients diagnosed as PEX without glaucoma, 15% will have increased IOP during 10-years of follow up.[4-7] The PEG is the most common cause of secondary open-angle glaucoma; furthermore, it has intraoperative complications such as iris zonular dialysis, posterior capsule rupture and vitreous loss.[5]

The Valsalva maneuver (VM) via forceful exhalation attempt against a closed airway frequently is performed during daily activities such as lifting something, doing physical exercise, vomiting, and coughing[6-7]. During the VM, the intra-thoracic pressure is increased and venous

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blood return to heart is decreased whereas left ventricular volume and pulse pressure are decreased[8-9]. The VM has some effects on the anterior chamber. The VM can cause a significant narrowing in the iridocorneal angle and shallowing at the central anterior chamber[10-11].

The VM might have an impact on clinical measurements and applications. Patients often hold their breath, causing an unintentional VM during ophthalmological examinations. Rafuse et al[8] suggested that the VM could affect intraocular pressure (IOP) due to increased intra-thoracic pressure and decreased ocular venous return. The increased intra-thoracic pressure and decreased ocular venous return during involuntary VM may affect both the anterior and posterior segment measurements, particularly in those with glaucoma. For this reason, we investigated the effects of VM on both corneal and anterior chamber as well as choroidal, retinal and optic nerve parameters in patients with PEG.

MATERIALS AND METHODS

This prospective, observational study was conducted at Training and Research Hospital of Afyonkarahisar Health Sciences University between January 2017 and August 2017. The study included 53 eyes of 30 patients with PEG. The study was performed in accordance to tenets of the Declaration of Helsinki. The study protocol was approved by the Local Ethics Committee of Afyonkarahisar Health Sciences University.

All patients underwent a thorough ocular examination including a best-corrected visual acuity measurement with refractometer, anterior segment examination with slit-lamp microscopy, and intraocular pressure (IOP) measurements by applanation tonometry, and dilated fundus examination. Patients were excluded if they had a history of severe systemic diseases (such as diabetes, hypertension, vasculitis and renal failure), retinopathy and previous refractive surgery of the eye. Also, patients with any illness restricting VM were excluded.

The inclusion criteria were glaucomatous optic disc damage (the presence of focal thinning of the neuroretinal rim or notching and an optic disc retinal nerve fiber layer defect) and glaucomatous VF defect; clinically evident PEX syndrome defined as having PEX material deposits on the pupil margin, anterior chamber and the lens capsule at initial evaluation.

The VM was performed with expiratory pressure ranging between 35 and 40 mmHg by blowing through the mouthpiece attached to a spirometry with a manometer during the examination (B-Spiro Triball Volumetric Spirometer, Bicakcilar, Istanbul, Turkey). The SD-OCT and Sirius Scheimpflug-Placido Topographer (Costruzione Strumenti Oftalmici, Florence, Italy) measurements were performed before (resting position) and during VM (during the phase 1 of the VM [between 5 to 15 seconds of VM]) by the same clinician (AA). Central corneal thickness (CCT), iridocorneal angle (ICA) and anterior chamber depth (ACD) measurements (Figure 1) were performed with the

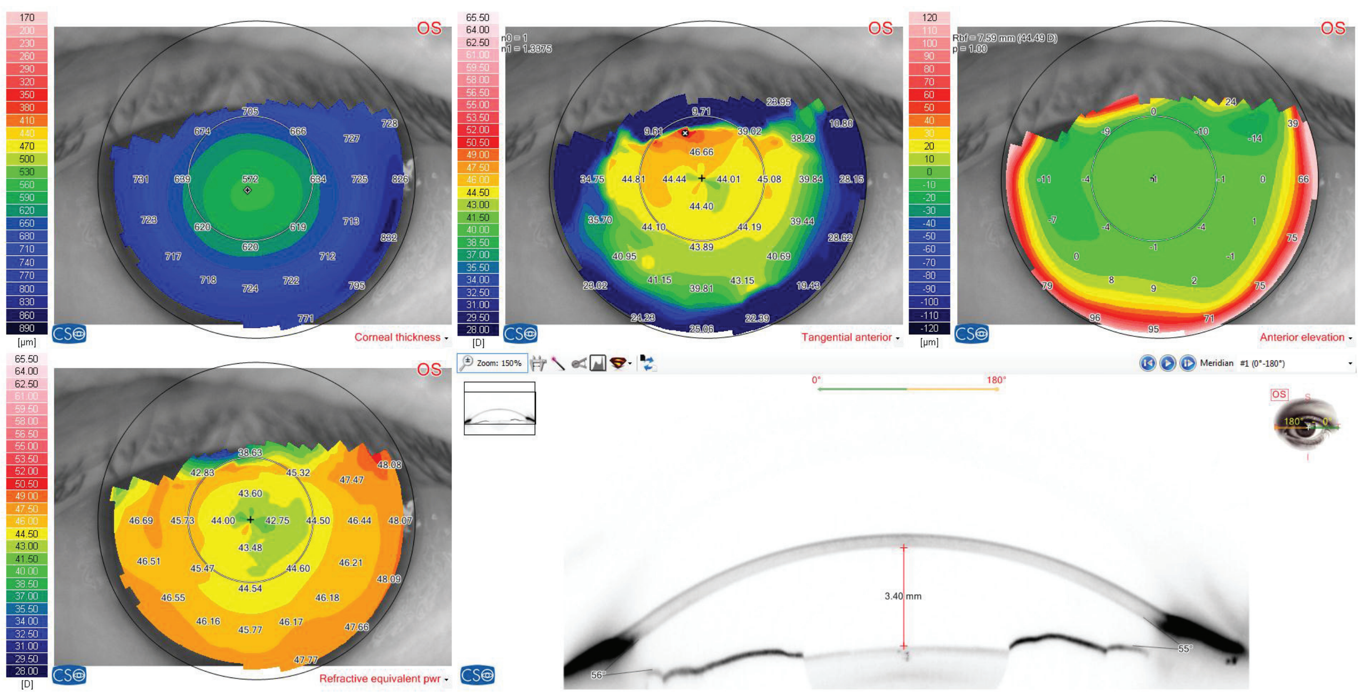

Figure 1a. *Anterior chamber depth, iridocorneal angle central corneal thickness before Valsalva maneuver.*

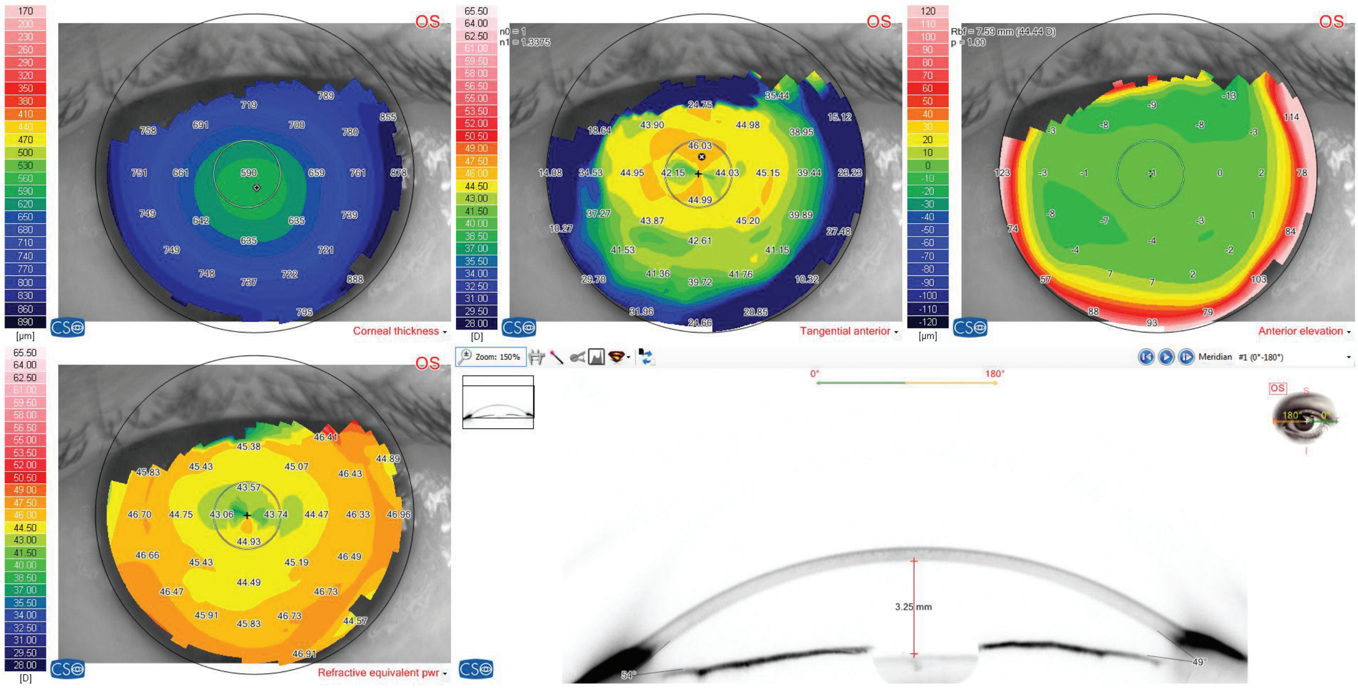

Figure 1b. *Anterior chamber depth, iridocorneal angle central corneal thickness after Valsalva maneuver.*

Sirius Topographer while central macular thickness (CMT) (Figure 2), optic disc retinal nerve fiber layer (OD RNFL) (Figure 3) and subfoveal choroidal thickness (CT) (Figure 4) measurements were performed by SD-OCT.

Statistical analysis

Statistical analysis was performed with IBM SPSS 24 (SPSS Inc, Chicago, Illinois, USA) and the paired sample *t-test* was used to compare the parameters measured

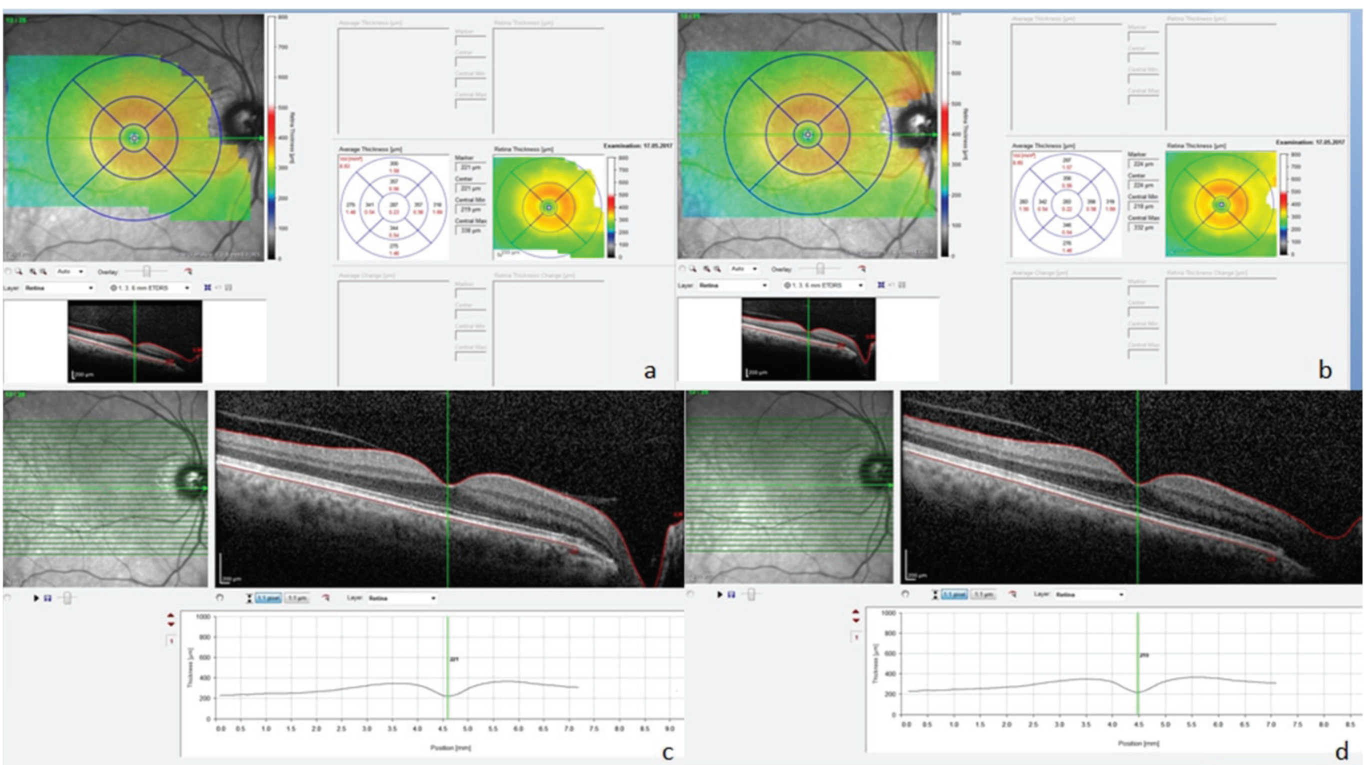

Figure 2. *Macular changes during the Valsalva maneuver. The figure (a) and (c) show before Valsalva maneuver; the figure (b) and (d) show after valsalva maneuver*

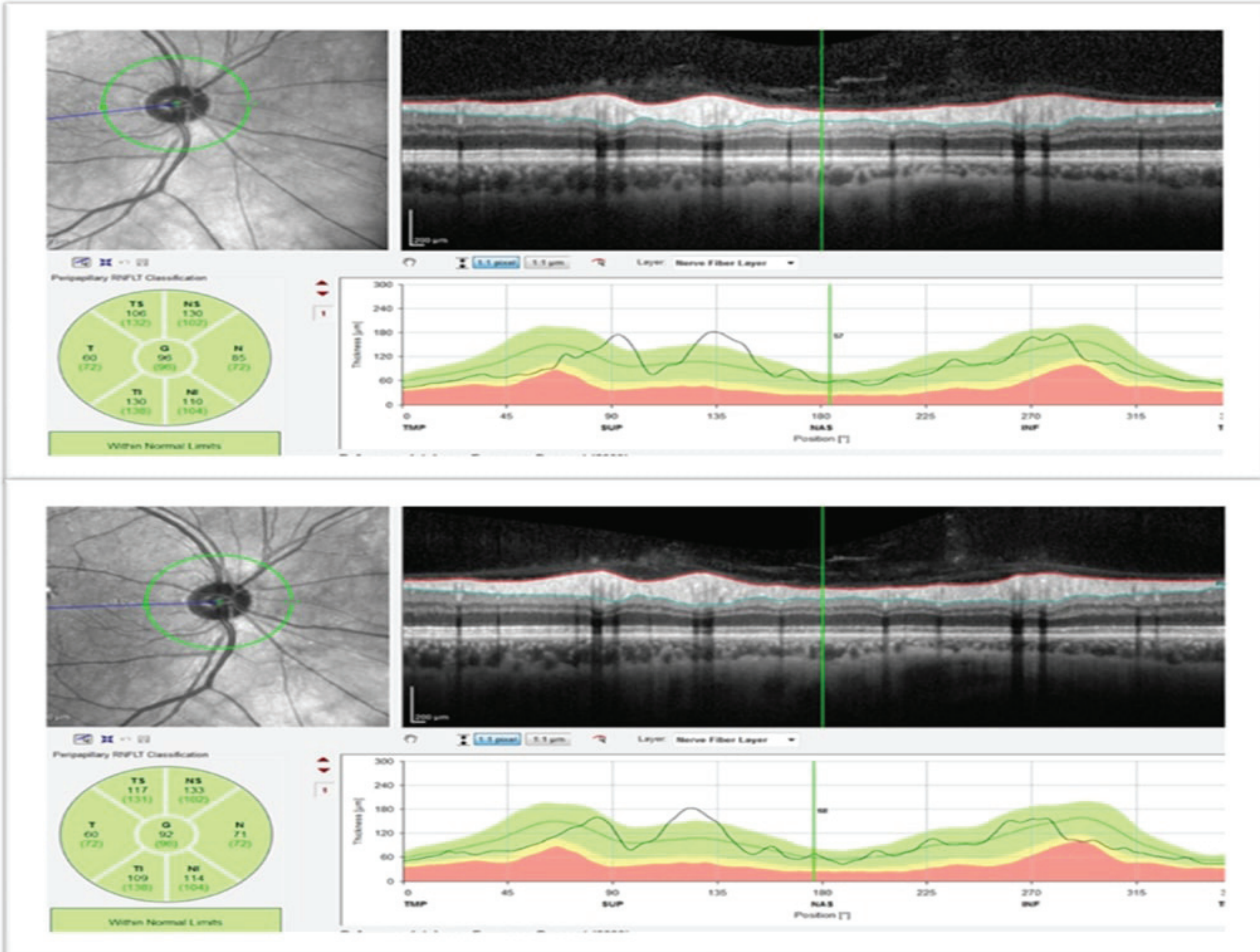

Figure 3. *OD RNFL changes before (superior) and after (inferior) Valsalva maneuver.*

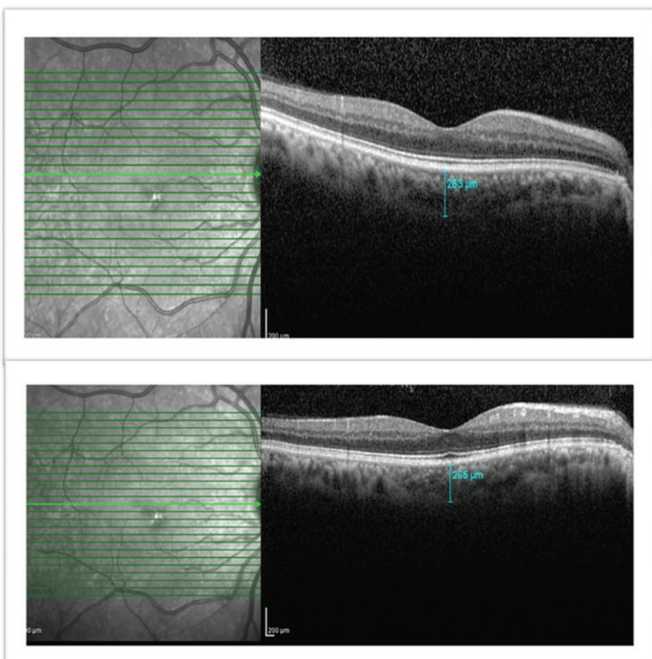

Figure 4. *The changes on subfoveal choroidal thickness before (superior) and after (inferior) Valsalva maneuver.*

before and during VM. A p value < 0.05 was considered as statistically significant.

RESULTS

The study included 53 eyes of 30 patients. Of 53 eyes included, 36 (67.9 %) were men and 17 (32.1%) were women. The mean age was 67.27± 8.14 years in male patients and 66.11±9.33 years in female patients. The mean age was 66.9±8.20 (49-80) years in the study population. The CCT was increased from 536.2±33.5 µm before VM to 537.5±35.8 µm during VM (p=0.237) but the difference did not reach statistical significance. The difference was -1.37±8.37 µm in CCT. OD-RNFL parameters were significantly lower during VM (81.6±21.2µm) compared to those obtained before VM (82.1±21.5 µm; p=0.034). There was a decrease in ICA (42.5°±9 before VM, 42.0°±9 during VM, p=0.188), ACD (3.39±0.6 mm before VM, 3.38±0.6 mm during VM, p=0.082) and CMT (218.9±25µm before VM, 217.5±24 µm and during VM, p=0.830); however, the differences did not reach statistical significance. The mean change recorded was 0.47±1.6 µm on OD RNFL parameters. The mean change recorded was 1.45±6 µm for CMT, 0.5°±3 for ICA and 0.01±0.04 mm for ACD. There was a significant increase in subfoveal CT (213.3±40.9 µm before VM; 224.0±40.0 µm during VM; p‹0.001) and the mean change recorded was -10.7±14.7 µm (Table 1).

DISCUSSION

There are only a few studies about the effects of the VM on the corneal morphology, anterior chamber, and macula in the literature. In this study, we aimed to determine corneal changes, iridocorneal changes, optic disc and macula parameters before and during VM. The normal physiological response to VM includes 4 phases[12]. The first phase is approximately 15 seconds and majority of ophthalmological studies investigated the effects of the VM on ocular structures in this phase[12-13]. It is predictive that anterior chamber parameters such as anterior chamber depth (ACD) and iridocorneal angle (ICA) are decreased. In a prospective, observational study, Wang et al[10] found that the central ACD of subjects became more shallow (from 2.286 to 2.262 mm, p<0.01) and the anterior chamber angle became more narrow (from 14.673 to 13.370 degrees, p=0.04) during Valsalva maneuver in a group of patients with narrow angles and in normal control subjects. Wang et al[10] postulated that the increased choroidal volume during the Valsalva maneuver reduces venous return and increases peripheral venous pressure, resulting in decreased ocular venous return, thus increasing the blood and fluid volume in the ocular tissues.

In a prospective, observational study on 35 eyes of 35 healthy volunteers, Pekel et al.,[14] that central corneal thickness, corneal volume, iridocorneal angle, anterior chamber depth, and anterior chamber volume were decreased markedly during the VM. In a prospective, interventional case series including 9 healthy volunteers, Falcão et al.[15] suggested that there was no statistically significant difference in choroidal thickness at rest or during Valsalva maneuver in any of the groups compared; however, such increase in anterior choroidal thickness may cause changes in anterior chamber parameters. Dada T. et al.[11] founded that possible mechanisms of significant elevation in intraocular pressure and narrowing of the anterior chamber angle recess are thickening of the ciliary body and increase in the iris thickness in eyes with suspected primary adult glaucoma during the Valsalva maneuver. In our study, the ICA (42.5° before VM, 42.0° during VM, p=0.188) and ACD (3 mm before VM, 3.38 mm during VM, p=0.082) were decreased but the difference did not reach statistical significance. On contrary to the study by Pekel et al.,[14] we found an increase in CCT value during VM compared to resting position (536.2 µm before VM, 537.5 µm after VM, p=0.237), but the difference did not reach statistical significance.

In a prospective, cross-sectional study, Li et al.[16] suggested that the different layers of the retina and the choroidal thickness (CT) showed no significant changes, but the anterior chamber parameters were decreased markedly compared to the baseline. In the study, Kurultay-Ersan et al.[17] investigated effects of VM on ocular parameters in the total of 60 high myopic (≥6.0 D) and 50 high hyperopic (≥+3.0D) eyes of 58 patients aged 19-65 years. Authors demonstrated that mean choroidal thickness was significantly increased during VM and that mean central macular thickness and mean disk RNFL thickness was higher in hyperopic patients than high myopic patients but Valsalva maneuver was not associated with significant changes in central macular or disk RNFL thicknesses. In the study by Zhang et al.,[18] IOP and lumbar CSF-P measurements were performed in 20 neurological patients in a lying position before and during a Valsalva maneuver. In the second part of the, 20 healthy subjects underwent ocular tonometry and confocal scanning laser tomography of the optic nerve head before and during a Valsalva maneuver. Authors found that IOP was increased and optic cup volume (p<0.001), cup/disc area ratio (p=0.02) and up/disc diameter ratio (p=0.03) were significantly decreased while neuroretinal rim volume (p=0.005) and mean retinal nerve fiber layer thickness (p=0.02) were significantly increased in healthy controls during VM. In our study, there was a decrease CMT (218.9 µm before VM, 217.5 µm after VM p=0.83) while optic disc-RNFL parameters were significantly decreased during the VM (82.1 before VM, 81.6 after VM, p=0.034). These findings were not in agreement with literature. However, we did not examine optic cup volume, cup/disc ratio, and optic cup depth in our study, comprising one of the limitations of our study.

We have also examined subfoveal choroidal thickness (CT) in eyes with PEG in our study. There are a few studies including comparing PEX with healthy volunteers or effects of choroidal thickness after VM; however, we could not find studies investigating CT on PEG patients. As mentioned previously, in the case series of 9 healthy volunteers, Falcão et al.[15] examined the choroidal thickness and found that there was no s significant difference in choroidal thickness at rest or during VM. Turan-Vural et al.[19] detected that PEX is associated with an overall thinning of the subfoveal choroid. Goktas et al.[20] reported that mean subfoveal, temporal and nasal choroidal thickness was significantly thinner in the PEX group compared with the healthy control group. Zengin MO et al.[21] found that PEX patients had lower mean choroidal thickness than controls, but there were no statistically significant. Bayhan et al.[22] compared 32 eyes of 32 patients PEG patients with 30 eyes of 30 age-matched healthy subjects and detected that nasal choroidal thickness of PXG patients were thinner than healthy subjects. Ozge et al.[23] reported that CT measurements were similar in 18 patients with PEG in one eye and PEX in the fellow eye and 39 healthy subjects. Moghimi et al.[24] detected that subfield of subfoveal area, the inner superior and the inner nasal quadrants of choroidal thickness were significantly lower in the PEX group compared to the control. Dursun et al[25] reported a decrease in choroidal thickness in the macular and peripapillary areas in patients with PEX and PEG. Çiçek et a.l[26] found a significant increase in choroidal thickness during the VM at the healthy volunteers. Eroglu et al.[27] investigated choroidal thickness in the eyes with PEX using OCT by comparing with healthy control; it was observed that clinically affected eyes of patients with PEX syndrome have significantly thinner choroids compared with healthy controls.

We did not examine the IOP of patients during VM. This is another limitation of our study. However, there are a few studies comparing IOP before and after VM. Brody et al.[28] studied effects of psychological stress and the VM on short-term variations in IOP in 49 healthy adults and found that all stressors caused a significant, transient increase in IOP, although the VM produced changes with a greater magnitude (10.2 mm Hg) than the psychological stressors (1.3 mm Hg). Rafuse et al.[8] detected that IOP was increase in normal and glaucomatous eyes after VM. Khan et al.[29] examined the difference in IOP and pulsatile ocular blood flow at three groups of patient (normal, untreated primary open-angle glaucoma and untreated normal-tension glaucoma) and detected that normal-tension glaucoma and normal groups had an increase in IOP, whereas the primary angle glaucoma showed drop in IOP during VM.

We assessed some studies applying mechanical stress that affects to ocular region in the literature. Liu Wc et al.[30] detected that corneal biomechanical parameters and IOP were affected by eye rubbing and breath-holding at normal subjects, but there are no significant differences in parameters. Moraes et al.[31] reported IOP peaks detected with the water drinking test were predictive for future visual field progression in a treated primary open-angle glaucoma population. Dos Santos et al.[32] examined the difference in IOP measurements by Goldmann applanation tonometry and Perkins hand-held applanation tonometry in 70 normal weight individuals who had no difficulties with IOP measurements at the slit lamp and 12 obese patients with suspected glaucoma. In this study, authors detected that there were transient IOP elevations after breath-holding and thorax compression.

Limitations of the study

This study did not include a healthy control group and we used the 'resting phase' measurements of the patients as the control values. We did not evaluate the changes of IOP values, optic cup and cup to disc ratio and visual field test during VM.

In conclusion, a significant increase in subfoveal CT and a significant decrease in RNFL were observed during VM in eyes with PEG but the increase in CCT and decrease in ACD and ICA values did not reach statistical significance in our study. There is a need for further studies regarding these parameters. In the light of these data, it is understood that intraocular pressure measurements should be repeated several times in patients with severe dyspnea and difficulty followed by severe lifting and severe vomiting, and changes in retinal, choroidal and corneal parameters should be considered.

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