ORIGINAL ARTICLE

The Effect of Laser Peripheral Iridotomy on Corneal Transparency in Patients with Acute Primary Angle Closure Glaucoma

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ABSTRACT

Purpose: To investigate the laser peripheral iridotomy (LPI) induced changes on corneal densitometry (CD) in cases with acute primary angle closure glaucoma (PACG) during the post-laser 1 month period.

Materials and Methods: This prospective study included 21 eyes with first acute attack of PACG. All the eyes underwent LPI with neodymium: yttrium-aluminum-garnet (Nd:YAG) laser after the intraocular pressure (IOP) decreased to normal levels with maximal anti-glaucoma treatment and complete regression of corneal edema. Central corneal thickness (CCT) and CD values were measured by densitometry software of Pentacam HR-Scheimpflug corneal topography over a 12-mm diameter of the cornea just before and at the first week and first month after LPI.

Results: The mean age of 13 female and 8 male cases was 56.6±7.9 years. The IOP during the acute attack was 47.5±4.2 mmHg and it decreased to 19.0±2.8 mmHg after medical treatment before LPI. Both the IOP and the CCT values decreased significantly values at the first week and month after LPI ($p<0.001$). Anterior, central, posterior and total corneal density values of at 0-2 mm zone, 2-6 mm zone, 6-10 mm zone and corneal density values of total zones decreased significantly at the first week and month after LPI.

Conclusion: The corneal densitometry values were found to be decreased after LPI in acute PACG during the first month and this result was thought to be caused by the decrease in IOP and the regression of corneal edema due to LPI.

Keywords: Corneal densitometry, corneal edema, laser peripheral iridotomy, primary angle closure glaucoma.

INTRODUCTION

Acute primary angle-closure glaucoma (PACG), a subgroup of PACG, is characterized by blurred vision, halos, ocular pain, high intraocular pressure (IOP), corneal edema, mid-dilated pupil and some systemic findings like headache, nausea and vomiting due to the sudden closure of iridocorneal angle (ICA).[1] This dramatic clinical condition is caused by acute apposition of iris to the trabecular meshwork and emergency treatment is necessary.[1]

Generally maximum medical topical and systemic antiglaucomatous agents are used as first-line therapy in order to reduce IOP rapidly and improve the symptoms.[1] In addition to medical treatment, laser peripheral iridotomy (LPI) and argon laser peripheral iridoplasty (ALPI) are two important laser procedures used in acute PACG. LPI is an effective method in acute PACG especially in the absence of peripheral anterior synechia (PAS) and it balances the pressures of anterior and posterior chambers.[1-4]

Corneal transparency is known to be correlated with decreased corneal backscatter and can be quantified by measuring backscattered light.[5-7] The Pentacam Scheimpflug system (Oculus, Wetzlar) can analyze the corneal backscattered light and measure the corneal density (CD) in 3 layers and 4 annular zones.[5-8] Increased CD can signify corneal edema even undetectable by slit-lamb examination. Here in this study, our purpose was to investigate the LPI-induced changes in CD in acute PACG cases during the post-laser 1 month period.

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MATERIALS AND METHODS

This prospective study included 21 eyes of 21 cases with first acute attack of PACG who had applied to emergency department of Ulucanlar Eye Research Hospital between March 2018 and January 2019. All the eyes underwent LPI with neodymium: yttrium-aluminum-garnet (Nd:YAG) laser after the IOP decreased to normal levels with maximal systemic and topical anti-glaucoma treatment and complete regression of clinically significant corneal edema. All of the study procedures were conducted in accordance with the Declaration of Helsinki, and informed consents were taken from all of the participants. This study was approved by The Ethical Committee of Numune Training and Research Hospital. All patients were Turkish Caucasians.

During the acute attack ocular examination was performed at the emergency department including best-corrected visual acuity (BCVA) with Snellen charts, slit-lamb examination, fundus examination by +90 D lens, IOP measurements with Goldmann applanation tonometry, gonioscopy of the fellow eye with Goldmann three-mirror lens. Gonioscopy and fundus examinations were performed for the eyes with acute PACG after the regression of corneal edema. Also at the first week after LPI, retinal nerve fiber analysis with optical coherence tomography (OCT) and visual field analysis with Humphrey perimetry were performed in all cases before CD measurements.

The inclusion criteria of the acute PACG were cases with first attack, high IOP (>40 mmHg), corneal edema, red eye, mid-dilated pupil and the presence of the symptoms like blurred vision, halos, ocular pain, headache, nausea and vomiting. Also closed or narrow ICA (stage 0-2 according to Shaffer grading system) was helpful for us in the diagnosis. The cases who had histories of any types of glaucoma or increased IOP before, any corneal diseases like keratoconus, corneal opacity, dry eye or any ocular surface diseases, ocular surgery or laser treatment, trauma, uveitis or other inflammation and contact lens use and diabetic cases were excluded. The eyes with pseudoexfoliation, PAS, glaucomatous OCT and perimetric findings and with poor image quality were not included to the study. Also the cases who needed antiglaucomatous agents after first week of LPI or who had cataract surgery within the first month of LPI were excluded.

All the cases had intravenous infusion of mannitol 20% (250-300 cc) at the emergency department. Oral acetazolamide 250 mg (3 times daily), oral potassium supplement, topical fixed-combination of beta-blocker and carbonic anhydrase inhibitors (twice daily) and brimonidine (twice daily). LPI procedures were performed within the first day of the attack (after 12-24 hours) by the same experienced physician (OB) with neodymium: yttrium-aluminum-garnet (Nd:YAG) laser under topical anesthesia with proparacain 0.5%. Superior-nasal position (1 or 11 o'clock) was focused and one or more shots were performed (1-3 pulses per shot with 3-8 mJ energy). Loteprednol etabonate 0.5% eye drop was instilled three times daily for 3 days. All the cases were examined at the first, third and fifth days after LPI and antiglaucomatous agents were decreased gradually until the seventh day. Also at the first week, retinal nerve fiber analysis with optical coherence tomography (OCT) and visual field analysis with Humphrey perimetry were performed in all cases before CD measurements.

Central corneal thickness (CCT) and CD values were measured by densitometry software of Pentacam HR-Scheimpflug corneal topography just before LPI and at the first week and the first month after LPI. All the measurements were performed by the same experienced clinician between 9 am and 2 pm under standard dim-light conditions without pupil dilatation. The CD values of anterior layer (anterior 120 µm), central (between anterior layer and posterior 60 µm), posterior layer (posterior 60 µm) of 4 annular concentric zones as 0-2 mm zone, 2-6 mm zone, 6-10 mm zone and 10-12 mm zone were measured. The CD values were expressed in grayscale units (GSC) as 0 for maximum transparency and 100 for total corneal opacity.

Statistical analysis was performed using SPSS v.21.0 for Windows (SPSS, Inc., Chicago, IL, USA). The normality of the data distribution was evaluated by Kolmogorov smirnov test. The pre and post-laser parameters were compared by paired *t*-tests. P values less than 0.05 were considered statistically significant.

RESULTS

The mean age of 13 (61.9%) female and 8 (38.1%) male cases was 56.6±7.9 (42-76 years). Nine cases had acute attack in the right and 12 cases had in the left eyes. The visual acuities were 20/200 in 5 eyes, counting fingers in 14 eyes and hand motion in 2 eyes before the treatment.

The IOP during the acute attack was 47.5±4.2 mmHg and it decreased to 19.0±2.8 mmHg after maximum medical treatment before LPI. The mean IOP values at the first week and month after LPI were 16.7±1.6 mmHg and 15.9±1.8 mmHg respectively ($p<0.001$) (Table 1). The mean CCT values were 529.8±17.1 µm just before LPI after the regression of corneal edema, 525.1±16.2 µm and 524.2±15.3 µm at the first week and month after LPI

respectively (Table 1). None of our cases complained about glare, halos or blurred vision after the IOP decreased to normal levels and corneal edema regressed after maximal medical treatment.

Anterior, central, posterior and total CD values of at 0-2 mm zone, 2-6 mm zone, 6-10 mm zone, 10-12 mm zone and total zones were summarized in table 2. The mean total CD values of the zones were summarized in figure 1. All the CD values decreased significantly at the first week and month after LPI. Also the CD values of the anterior, central and posterior layers of 0-2 mm zone at the first week were significantly higher than the values of the first month (p=0.012, p=0.006, and p=0.025, respectively). Similarly the CD values of the anterior, central and posterior layers of 2-6 mm zone at the first week were significantly higher than the values of the first month (p=0.03, p=0.005, and p=0.023, respectively). Also the mean CD values of total zones and layers were significantly higher than the values of the first month (p<0.05 for all).

DISCUSSION

Increased corneal back-scattering of light might be an indicator and objective tool for measuring mild corneal edema in spite of transparent appearance in slit-lamp examination. Here in this study, we examined the cases with first acute attack of PACG who had LPI after complete clinical regression of corneal edema with normal IOP levels. Our aim was to quantify corneal edema by measuring CD

Table 1: *The intraocular pressure and central corneal thickness values of the participants.*

	IOP (mmHg)	CCT (µm)
During the attack	47.5±4.2	-
Before LPI	19.0±2.8	529.8±17.1
First week	16.7±1.6 (p<0.001)*	525.1±16.2 (p<0.001)*
First month	15.9±1.8 (p<0.001)**	524.2±15.3 (p<0.001)**

LPI: Laser peripheral iridotomy, **IOP:** Intraocular pressure, **CCT:** Central corneal thickness, **IOP during the attack:** without any treatment, **IOP before LPI:** with maximal medical treatment, **IOP at first week and month:** without any treatment. **CCT during the attack:** It couldn't be measured in all eyes. *paired sample t-test, between before LPI and 1st week. **paired sample t-test, between before LPI and 1st month.

Table 2: *The corneal density values of the participants at the 1st day, 7th day, and 1st month.*

	0-2 anterior	**0-2 center**	**0-2 posterior**	**0-2 total**
1 day	26.8	12.5	9.8	16.3
7 day	25.2 (p=0.001)*	11.7 (p<0.001)*	9.1 (p<0.001)*	15.2 (p<0.001)*
30 day	24.8 (p=0.002)**	11.6 (p<0.001)**	9 (p<0.001)**	15.1 (p<0.001)**
	2-6 anterior	**2-6 center**	**2-6 posterior**	**2-6 total**
1 day	25.1	11.8	10.1	15.4
7 day	23.7 (p<0.001)*	10.9 (p<0.001)*	9.3 (p<0.001)*	14.3 (p<0.001)*
30 day	23.5 (p<0.001)**	10.8 (p<0.001)**	9.2 (p<0.001)**	14.2 (p<0.001)**
	6-10 anterior	**6-10 center**	**6-10 posterior**	**6-10 total**
1 day	29.1	17.5	13.8	19.7
7 day	28.2 (p<0.001)*	16.4 (p<0.001)*	12.9 (p<0.001)*	18.6 (p<0.001)*
30 day	28.2 (p<0.001)**	16.3 (p<0.001)**	12.8 (p<0.001)**	18.5 (p<0.001)**
	10-12 anterior	**10-12 center**	**10-12 posterior**	**10-12 total**
1 day	33.3	21.2	16.7	24.8
7 day	31.7 (p<0.001)*	20 (p<0.001)*	15.7 (p<0.001)*	23.5 (p<0.001)*
30 day	31.5 (p<0.001)**	19.8 (p<0.001)**	15.6 (p<0.001)**	23.4 (p<0.001)**
	Total anterior	**Total center**	**Total posterior**	**Total total**
1 day	28.3	15.5	12.5	19.1
7 day	26.9 (p<0.001)*	14.7 (p<0.001)*	11.8 (p<0.001)*	18.3 (p<0.001)*
30 day	26.8 (p<0.001)**	14.6 (p<0.001)**	11.6 (p<0.001)**	18.1 (p<0.001)**

*paired sample t-test, between before LPI and 1st week.
**paired sample t-test, between before LPI and 1st month.

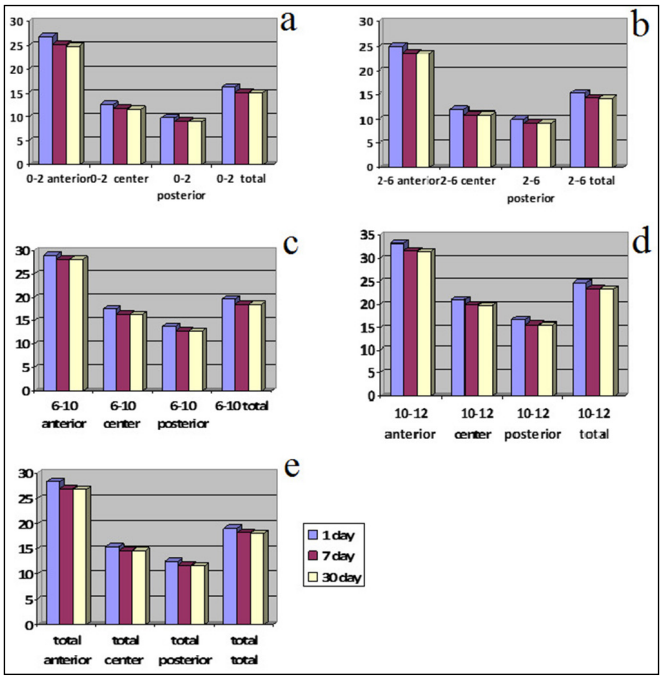

Figure 1. *The corneal density values of the cases at the 1st day, 7th day, and 1st month (zones; a: 0-2 mm, b: 2-6 mm, c: 6-10 mm, d: 10-12 mm, e: total).*

in spite of clinically transparency and investigate the LPI-induced changes in CD in acute PACG cases during the post-laser 1 month period.

As there can be corneal back-scattering of light even in the eyes with transparent cornea, Cankaya et al.[5] investigated the effects of age, gender, refractive status and some corneal parameters on CD in healthy cases. They had 588 healthy cases between 6 and 76 years-old in their study. They observed a significant positive correlation between age and total CD and concluded that increased CD was the effect of aging. But no significant associations were found between CD and CCT, corneal volume, corneal power and refractive status of the eye. Similarly Garzón et al.[6] found significant correlation between increased CD and age, while no additional effects of CCT, keratometry and spherical equivalent were observed. Different from the two studies above, Pekel et al.[7] did not find a significant association between CD and age in healthy subjects. Also they observed significant negative correlation between CD and the thickness of Bowman's layer and concluded that corneal stroma might be more transparent in people with thicker Bowman layer.[7]

Tekin et al.[8] tried to answer whether CD might be used as an indicator of the health of cornea. They investigated the correlations between CD and corneal endothelial cell density, average cell area, coefficient of variation (CV) of the cell area, maximum cell area, minimum cell area, and percentage of hexagonal cells (HEX) were measured by a specular microscope.[8] They found inversely and moderately correlations between CD and HEX, but positively and moderately correlations between CD and CV. They stated that CD might be used as an indicator of the health of cornea.

Some studies have been reported about the changes of CD in some ocular and systemic pathological conditions. Koc et al.[9] stated that increase in CD might be an early finding of keratoconus. They especially observed increased CD in anterior layers of the central zone in subclinical keratoconus cases and stated that this might be related with the pronounced effect keratokonus on anterior layer of central part of the cornea.

In the current study all our cases had acute PACG with their first attack. They all had massive corneal edema with increased IOP during the attack and complete clinical regression of edema occurred with maximal medical antiglaucomatous agents. In spite of transparency in slit-lamb examination, there might be subclinical cornea edema in the cases. So we measured CD within the first day of attack just before LPI and repeated the measurements at the first week and month. Our aim was to evaluate the subclinical cornea edema during the first month after the attack and also the effect of LPI. None of our cases had histories of glaucoma or increased IOP before. All had normal OCT and visual field findings and none of them needed antiglaucomatous agents after first week of LPI. We excluded the cases with glaucoma because glaucoma and/or the antiglaucomatous agents might affect CD. In our previous study we investigated the effect of topical latanoprost on corneal clarity in glaucoma cases.[10] We observed decrease in CD with long-term use of latanoprost and thought that the result was related with the IOP reduction. Although all the cases had clinically transparent cornea at the time of first CD measurement just before LPI, we observed statistically significantly decreases in CD at the first week and month after the laser procedure. Also we observed significantly higher CD values at the first week in all layers of 0-2 mm and 2-6 mm zones than the first month. Similarly the mean total CD at the first week was found to be significantly higher than the first month and these results were thought to be an indicator for the continuation of the regression of cornea edema.

Ishikawa et al.[11] measured CD in their cases who had undergone cataract surgery preoperatively and on days 1, 3 and 7 after the surgery. They observed significant increase at the first day and decrease to preoperative values at the first week. They stated that the measurement of CD was

a diagnostic tool for undetectable corneal edema by slit-lamp examination. The main reasons for cornea edema in their study were the surgical inflammation and trauma but in our cases it was rapid increase in IOP. IOP decreased to normal levels by maximal medical antiglaucomatous treatment and the cornea seemed transparent in all our cases at the first day just before LPI. But CD continued to decrease at the first week and month after LPI and it was thought to be an indicator for the continuation of the regression clinically insignificant cornea edema due to the decrease in IOP. We found that CD values were highest in the anterior layer and lowest in the posterior layer in all zones like in previous studies and thought that it was related with the fact that corneal epithelium was the main source for backscattering.[5,6]

As conclusion, CD was found to continue to decrease in acute PACG during the first month in spite of clinically insignificant corneal edema and it was thought to be due to the IOP decrease after LPI. To the best of our knowledge, this is the first study about CD measurements in acute PACG after LPI but the major limitation of our study was that we couldn't use confocal microscopy. The Pentacam Scheimpflug system may be used as a diagnostic tool in following-up clinically in significant corneal edema in all kinds of glaucoma particularly after laser or surgical procedures.

Acknowledgement/Disclaimers/Conflict of interest

The authors report no conflicts of interest and have no proprietary interest in any of the materials mentioned in this article. This article has been read and approved by all the authors. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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REFERENCES

1. Chan PP, Pang JC, Tham CC. Acute primary angle closure-treatment strategies, evidences and economical considerations. Eye (Lond) 2019;33:110-9.
2. Radhakrishnan S, Chen PP, Junk AK, et al. Laser peripheral iridotomy in primary angle closure: A report by the American Academy of Ophthalmology. Ophthalmology 2018;125:1110-20.
3. He M, Jiang Y, Huang S, et al. Laser peripheral iridotomy for the prevention of angle closure: a single-centre, randomised controlled trial. Lancet 2019;393:1609-18.
4. Yan C, Han Y, Yu Y, et al. Effects of lens extraction versus laser peripheral iridotomy on anterior segment morphology in primary angle closure suspect. Graefes Arch Clin Exp Ophthalmol 2019;257:1473-80.
5. Cankaya AB, Tekin K, Kiziltoprak H, et al. Assessment of Corneal backward light scattering in the healthy cornea and factors affecting corneal transparency. Jpn J Ophthalmol 2018;62:335-41.
6. Garzón N, Poyales F, Illarramendi I, et al. Corneal densitometry and its correlation witg age, pachymetry, corneal curvature, and refraction. Int Ophthalmol 2017;37:1263-8.
7. Pekel G, Özbakış F, Bahar A, et al. Correlations of corneal optical densitometry, endothelial hexagonality percentage and epithelium thickness. Curr Eye Res 2018;43:170-4.
8. Tekin K, Sekeroglu MA, Kiziltoprak H, et al. Corneal densitometry in healthy corneas and its correlation with endothelial morphometry. Cornea 2017;36:1336-42.
9. Koc M, Tekin K, Tekin MI, et al. An early finding of keratoconus: Increase in corneal densitometry. Cornea 2018;37:580-6.
10. Sen E, Inanc M, Elgin U. The effect of topical latanoprost on corneal clarity; 1-year prospective study. Cutan Ocul Toxicol 2019;38:253-7.
11. Ishikawa S, Kato N, Takeuchi M. Quantitive evaluation of corneal epithelial edema after cataract surgery using corneal densitometry: a prospective study. BMC Ophthalmol 2018;18:334.