Studying the changes of ocular wavefront aberrations after neodymium : yttrium aluminum garnet laser capsulotomy

Nermeen M. Badawi

Aimof the study The aim of this study is to evaluate the changes of wavefront aberrations after performing neodymium : yttrium aluminum garnet (Nd : YAG) laser posterior capsulotomy for the management of posterior capsular opacifications.

Patients and methods This study is a prospective study that was performed on 100 eyes of 87 patients with posterior capsule opacification following phacoemulsification, in the period from March 2017 to October 2017. A complete ophthalmic examination and optical wavefront imaging were performed to every patient. Patients underwent posterior capsulotomy using Nd : YAG laser with a follow-up period of 6 months.

Results There were no significant changes in postoperative refraction at *P* value more than 0.05 still the best-corrected visual acuity showed a clinically significant at *P* value less than 0.05.
The intraocular pressure was statistically significantly increased on the first postoperative day ($P<0.05$) but not in other postoperative visits.
Regarding higher order aberrations there was a statistically significant improvement in total third-order aberrations ($P<0.05$), coma aberration ($P<0.05$), total fourth-order aberrations ($P<0.05$), spherical aberration ($P<0.05$), and total higher order aberrations ($P<0.05$) while quadrafoil and fifth-order aberrations showed no statistically significant changes.

Conclusion Nd : YAG laser posterior capsulotomy causes a significantly decrease in wavefront aberrations in patients with posterior capsule opacification.

Sci J Al-Azhar Med Fac, Girls 2018 2:189–193

The Scientific Journal of Al-Azhar Medical Faculty, Girls
2018 2:189–193

Keywords: aberrations, capsulotomy, wavefront, yttrium aluminum garnet laser

Ophthalmology department, Menoufia University, Shebin Elkom, Menoufia, Egypt

Correspondence to Nermeen M. Badawi, MD, FRCS Ophth (Glasgow), Compound Lake View, 90th Street, Villa 3/1, New Cairo, Cairo 11835, Egypt. Tel: +20 100 085 3835; fax: +20 222 606 654; e-mail: badawi.nermeen@yahoo.com

Received 16 August 2018 **Accepted** 4 December 2018

Introduction

Posterior capsule opacification (PCO) causes a decreased visual acuity after cataract surgery [1,2], through affecting the retinal image contrast causing significant glare, halos, and visual impairment [3,4]. Neodymium : yttrium aluminum garnet (Nd : YAG) laser is widely used for treating PCO to improve visual function [5] in spite of the fact that it may have effects on refraction, intraocular pressure (IOP) elevation, retinal complications, and intraocular lens complications, etc. [6], still it is considered as a safe procedure to manage PCOs [1].

This study detects the effect of YAG laser capsulotomy on higher order aberrations aiming to improve visual functions in patients with good visual acuity.

Patients and methods

Written informed consents were obtained from every patient before participating in the study.

The procedures followed the ethical standards and were approved by the Ethics Committee of Menoufia University and the Helsinki Declaration. Prior to any procedure the patient signed an informed consent.

This study is a prospective study that was performed on 100 eyes of 87 patients with PCO following phacoemulsification, in the period from March 2017 to October 20017 in the Nor Al-Hayah Center Cairo, Egypt.

Inclusion criteria

Patients with clinical PCO following an uneventful phacoemulsification with posterior chamber IOL implantation (in-the-bag placement).

Exclusion criteria

(1) Patients with a history of previous history of other ocular surgeries.
(2) Coexisting ocular diseases other than PCO.

Preoperative assessment

All eyes included in this study were subjected to detailed preoperative assessment, which included

uncorrected visual acuity, best-corrected visual acuity at a distance using a logarithm of the minimum angle of resolution scale, refractive status using an autorefractometer (KR-8100; Topcon Corporation, Tokyo, Japan), IOP measured by pneumatic tonometer (CT-80; Topcon Corporation), fundus evaluation using an indirect ophthalmoscope (Neitz, Tokyo, Japan), and optical wavefront imaging with measurement of higher order aberrations (Allegro Oculyzer; Wavelight Laser Technology AG, Wetzlar, Germany) were obtained.

Surgical technique

All laser posterior capsulotomies were performed by the same surgeon using Nd : YAG laser (Visuals; Zeiss, Oberkochen, Germany).

Prior to the procedure the following eye drops were installed:

(1) Tropicamide 1% and phenylephrine 2.5% eye drops for pupillary dilatation.
(2) Propacaine hydrochloride eye drops 0.5% for topical anesthesia.
(3) Apraclonidine hydrochloride 0.5% eye drops to prevent elevation of IOP after the laser.

A 12-mm Abraham contact capsulotomy lens (Ocular Instruments Inc., Bellevue, Washington, USA) was used with 2% hypromellose gel as the coupling agent.

Single-pulse mode Nd : YAG laser was used with the minimal power necessary to obtain breakdown of the posterior capsule to create an opening in the posterior capsule about 4 mm.

The amount of total energy and the number of shots were recorded.

Prednisolone acetate 1% eye drops four times per day and apraclonidine hydrochloride 0.5% two times per day for 5 days were prescribed for all patients. Topical 1% prednisolone acetate was prescribed to all patients four times a day for 1 week.

Patients had postoperative follow-up visits at 1, 3 days, 1 week, 1, 3, and 6 months postoperatively.

Evaluation was done using the same machines in preoperative and postoperative evaluation.

Data were collected, tabulated, and analyzed using the paired *t* test.

Results

The study included 100 eyes of 87 patients 34 men and 53 women with their ages ranging between 52 and 71 years with a mean of 61.1±6.4 years.

As for the best-corrected visual acuity in logarithm of the minimum angle of resolution units it was 0.79±0.17 preoperatively and 0.21±0.17 by the end of the postoperative period with a statistically significant improvement ($P<0.05$).

Regarding the changes in refraction, the spherical equivalent was −0.75±1.25 D preoperatively and 0.00 ±0.75 D postoperatively with no statistically significant changes ($P>0.05$).

Regarding the IOP as shown in Table 1, there was a statistically significant increase of IOP level in the first postoperative day ($P<0.05$), while in other postoperative visits, there was no statistically significant difference of IOP level in comparison with the preoperative level ($P>0.05$).

Regarding the changes in wavefront aberrations the root mean square (RMS) (square root of the mean of the square of all of the wavefront aberration values across the pupil) was used used to measure the magnitude of wave aberrations. The data listed in Table 2 shows that by the end of the follow-up period there is a statistically significant improvement in total third-order aberrations ($P<0.05$), coma aberration ($P<0.05$) (Fig. 1), total fourth-order aberrations ($P<0.05$), spherical aberration ($P<0.05$), and total higher-order aberrations ($P<0.05$) as well as the total aberrations ($P<0.05$).

Discussion

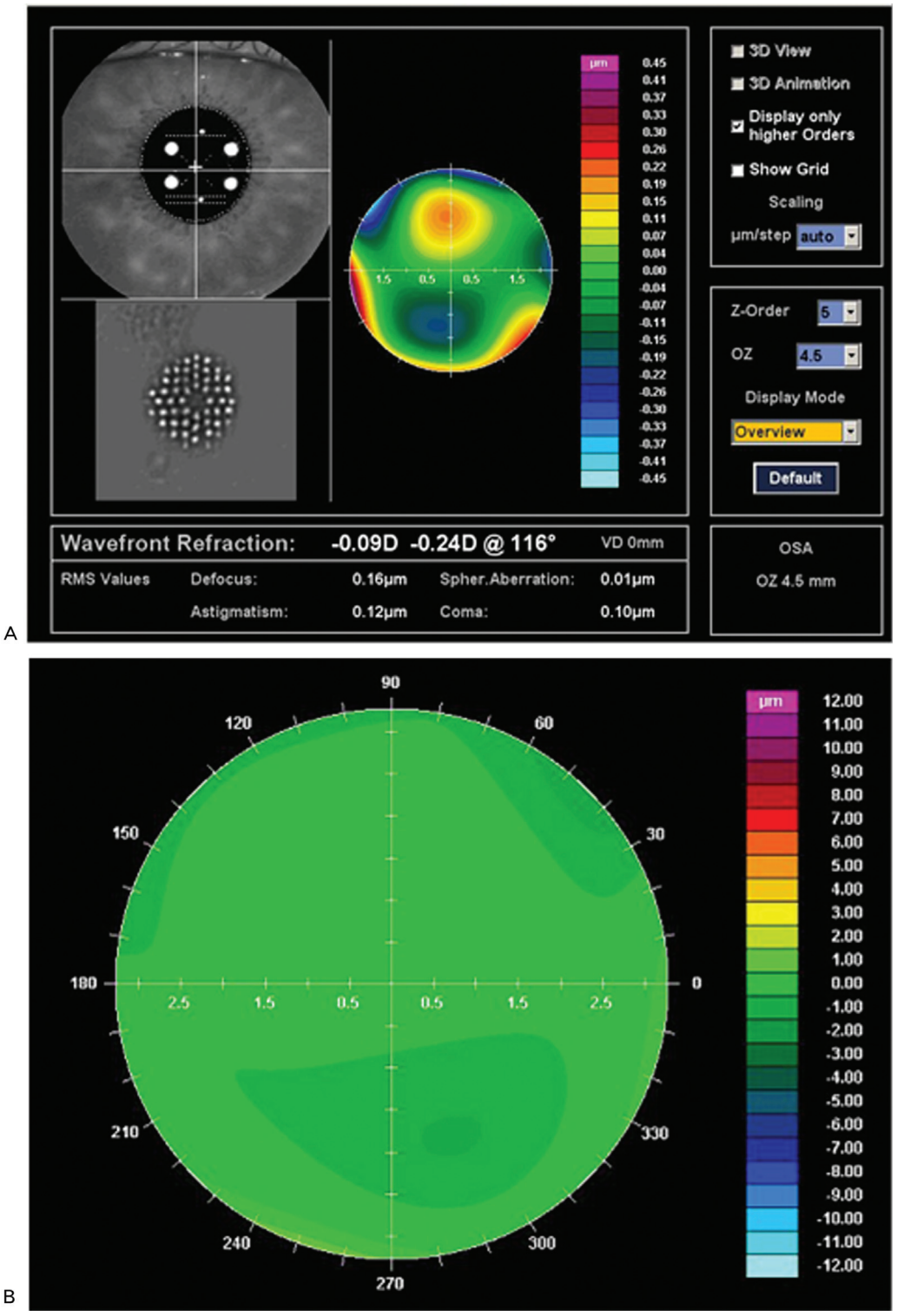
Nd : YAG laser posterior capsulotomy was proved to be an effective procedure in the treatment of PCO [6] in spite of the fact that the idea is to improve visual acuity through elimination of opacification; however, some patients with PCO not affecting their visual acuities

Table 1 Intraocular pressure changes

	IOP
Preoperative	15.4±2.64
First day postoperatively	19.7±3.93
Third day postoperatively	16.8±2.87
1 week postoperatively	15.9±2.78
1 month postoperatively	15.6±2.63
3 months postoperatively	15.4±2.72
6 months postoperatively	15.5±2.57

IOP, intraocular pressure.

Figure 1



(a) Preoperative prominent coma aberrations and (b) postoperative corrected coma aberrations.

might face other problems such as blurring of vision, glare, and halos, complications that were noticed by Yotsukura *et al.* [7], with wavefront aberrations considered to be the cause of these complaints regardless of its effect on refraction, as in the current study where no significant changes were encountered regarding refraction with similar results reached by Thornval and Naeser [8], Chua *et al.* [9], and Levy *et al.* [10]; however, Findl *et al.* [11] recorded a hyperopic shift caused by subtle posterior displacement of the lens.

One of the most common complications of Nd : YAG laser posterior capsulotomy is increased IOP. Even

Table 2 Changes in wavefront aberrations

	Preoperative	Postoperative	*P* value
The mean RMS value of third-order aberrations	0.625±0.074	0.326±0.015	0.014
The mean RMS value of coma aberrations	0.214±0.031	0.019±0.008	0.009
The mean RMS value of trefoil aberrations	0.164±0.011	0.019±0.003	0.092
The mean RMS value of fourth-order aberrations	0.492±0.053	0.261±0.008	0.011
The mean RMS value of spherical aberrations	0.155±0.006	0.154±0.005	0.008
The mean RMS value of quadrafoil aberrations	0.062±0.006	0.011±0.004	0.891
The mean RMS value of secondary astigmatism	0.072±0.006	0.054±0.005	0.020
The mean RMS value of fifth-order aberrations	0.050±0.006	0.029±0.004	0.104
The mean RMS value of sixth-order aberrations	0.044±0.003	0.039±0.003	0.031
The mean RMS value of total higher order aberrations	0.523±0.016	0.315±0.012	0.023
The mean RMS value of total aberrations	4.863±1.378	2.624±1.117	0.012

RMS, root mean square.

with prophylactic treatment, an elevated IOP level was reported in 15–30% of eyes by Pereira Minello *et al.* [12] and Lin *et al.* [13], respectively, while Keates *et al.* [14], had elevated IOP in only 0.6% of their patients, similarly Stark *et al.* [15] found that elevated IOP was 1.0% after Nd : YAG posterior capsulotomy. However, Shani *et al.* [16] did not find any increase of IOP and postulated that healthy nonglaucomatous eyes do not show increased IOP level after Nd : YAG laser posterior capsulotomy. Also Shah and Goulstine [17], did not find any IOP elevation in his study.

In this study, there was statistically significant increase of IOP level in the first postoperative day ($P<0.05$), while in other postoperative follow-up visits, there was no statistically significant difference in IOP level in comparison with the preoperative level ($P>0.05$).

Both quantity and quality of vision are decreased in the presence of ocular aberrations which prevent the formation of sharp focus of the object on the retina. For many years, ocular aberrations were believed to be myopia, hyperopia, and astigmatism only (low-order aberration). With the intervention of aberrometers, now many aberrations which were named higher order aberrations can be easily detected. The complexity of the shape of the wavefront image coming out of the eye is represented by the order of the aberrations, with the aberrations producing simple deformity of the wavefront image are of lower order (considered as first-order and second-order aberrations) while higher order aberrations (from third-order to sixth-order) refer to other types of aberrations (such as trefoil, tetrafoil, and coma aberrations); those produce a complex deformity of the wavefront image [18]. The effect of Nd : YAG laser capsulotomy on wavefront aberrations was subjected to evaluation by the current study that showed that there was statistically significant improvement of the mean postoperative RMS values in comparison with preoperative values of total third-order aberrations, coma aberration, total fourth-order aberrations, spherical aberration, secondary astigmatism, sixth-order aberrations, total higher order aberrations, and total aberrations ($P<0.05$).

Similar results were reached by Rozema *et al.* [19], with a statistically significant decrease regarding RMS values in all eyes including the total aberration and the higher order aberrations. Yotsukura *et al.* [7], who stated that after Nd : YAG posterior capsulotomy there was a statistically significant decrease in RMS of Zernike coefficients (S3) and the RMS of the total higher-order aberration, and Levy *et al.* [10], whose results showed a significant decrease in total, high-order aberrations, total trefoil, total tetrafoil, total spherical, and total high astigmatism aberrations with no significant changes in total coma aberrations.Those change led to a statistically significant improvement of the visual acuity whether in the current study in studies by Yotsukura *et al.* [7], Levy *et al.* [10], and Rozema *et al.* [19].

Conclusion

Nd : YAG laser posterior capsulotomy can effectively improve the quality of vision by decreasing the wavefront aberrations.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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