Optic coherence tomography measurement of choroidal and retinal thicknesses after uncomplicated YAG laser capsulotomy

Medidas das espessuras de coroide e retina após capsulotomia por YAG laser não complicada

İsa Yuvacı1, Emine Pangal1, Yudum Yüce1, Sumeysa Yuvacı1, Nurettin Bayram1, Dönüş Melek Ulusoy1, Ali Akalı2, Orhan Altunel1

ABSTRACT

Purpose: Optic coherence tomography (OCT) evaluation of the choroid, retina, and retinal nerve fiber layer after uncomplicated yttrium-aluminum-garnet (YAG) laser capsulotomy.

Methods: OCT analysis of retinal and choroidal structures was performed in 28 eyes of 28 patients following routine examinations before and 24 h, 72 h, 2 weeks, 4 weeks, and 12 weeks after YAG laser capsulotomy. Data were analyzed using the SPSS software.

Results: Data collected before YAG capsulotomy and at the above mentioned follow-up visits are summarized as follows. Mean central subfoveal choroidal thickness before YAG capsulotomy was 275.85 ± 74.78 µm; it was 278.46 ± 83.46 µm, 283.39 ± 82.84 µm, 280.00 ± 77.16 µm, 278.37 ± 76.95 µm, and 278.67 ± 76.20 µm after YAG capsulotomy, respectively. Central macular thickness was 272.14 ± 25.76 µm before YAG capsulotomy; it was 266.53 ± 26.47 µm, 269.14 ± 27.20 µm, 272.17 ± 26.97 µm, 270.91 ± 26.79 µm, and 273 ± 26.63 µm after YAG capsulotomy, respectively. Mean retinal nerve fiber layer thickness before YAG was 99.89 ± 7.61 µm; it was 98.50 ± 8.62 µm, 98.14 ± 8.69 µm, 99.60 ± 8.39 µm, 99.60 ± 8.39 µm, and 99.60 ± 8.35 µm after YAG capsulotomy, respectively. No observed change was statistically significant. No significant changes were observed with regard to mean intraocular pressure.

Conclusions: After YAG laser capsulotomy, no statistically significant changes were found in choroidal, retinal, and optical nerve fiber layer thicknesses, although slight thickness changes in these structures were observed, particularly during the first days.

Keywords: Choroid; Retina; Tomography, optical coherence; Posterior capsulotomy/methods

INTRODUCTION

Despite changes in lens design and advances in surgical techniques, the development of posterior capsular opacification (PCO) is the most common complication following cataract surgery. Although various methods to treat PCO have been attempted, neodymium:yttrium-aluminum-garnet (YAG) laser capsulotomy is yet the gold standard because it is non-invasive, can be applied rapidly under local anesthesia, and is effective. Various techniques to treat PCO have been attempted, including phacoemulsification of the posterior capsule, endocapsular laser capsulotomy, and irrigation and aspiration. The YAG laser is a good treatment choice because of its non-invasive nature and rapid effectiveness. However, posterior capsular opacification after uncomplicated YAG laser capsulotomy has been published (4-6). However, to the best of our knowledge, there are no publications regarding choroidal changes.

Therefore, we aimed to evaluate retinal and choroidal structures within the time periods when such changes are frequently observed. Potential positive findings could indicate whether optic coherence tomography (OCT) can be used for follow-up. We aimed to identify whether there were any changes at the 72-h follow-up, when inflammation after the procedure is high, and at 8-12 weeks after the procedure, when cystoid macular edema (CME) development is expected.

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1 Kayseri Training and Research Hospital Eye Clinic, Kayseri, Turkey.
2 Department of Ophthalmology, Harman University School of Medicine, Sanliurfa, Turkey.

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Corresponding author: İsa Yuvacı. Kayseri Training and Research Hospital Eye Clinic, Hastane Str, 38010 – Kocasinan, Kayseri – Turkey. E-mail: mdisay@hotmail.com
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METHODS

This prospective study was performed at the Ophthalmology Department of the Kayseri Education and Research Hospital. The study adhered to the tenets of the Declaration of Helsinki and was approved by the Local Ethics Committee of Erciyes University. All individuals received both oral and written information regarding the study, and each subject provided written and informed consent before participation in the study.

Patients were selected between December 2014 - March 2015, and the study involved 28 eyes of 28 patients suffering from PCO. The patients had to fulfill the following inclusion criteria: underwent cataract surgery with phacoemulsification and clinically observable PCO as observed by the slit lamp examination in only one eye; capable of being evaluated for at least 3 months after intervention by capsulotomy; and exhibited a centered intraocular lens (IOL) with complete overlap between the anterior capsule and IOL. Patients who had glaucoma, corneal or retinal disease, uveitis, previous laser treatments, ocular trauma, or surgery during the follow-up period were excluded.

All individuals underwent a screening process involving a complete ophthalmologic examination, including refraction and visual acuity, slit-lamp biomicroscopy, intraocular pressure measured using non-contact tonometry, and fundus examination. Data on retinal nerve fiber layer (RNFL) thickness, macular thickness, macular volume, and choroidal thickness were obtained using the Spectralis OCT (Heidelberg Engineering, Heidelberg, Germany) with the EDI modality. CEDI was defined as the central subfoveal choroidal thickness (CEDI) was measured using spectral-domain OCT (Spectralis, Wave-length: 870 nm; Heidelberg Engineering, Heidelberg, Germany).

Image acquisition: The procedure for obtaining enhanced depth imaging (EDI)-OCT has previously been described(7). The central subfoveal choroidal thickness (CEDI) was measured using spectral-domain OCT (Spectralis, Wave-length: 870 nm; Heidelberg Engineering, Heidelberg, Germany) with the EDI modality. CEDI was defined as the vertical distance from the hyporeflective line of Bruch's membrane to the hyporeflective line of the inner surface of the sclera. All subjects were imaged by the same experienced technician. Two independent clinicians measured CEDI, and the average of these measurements was used in the analysis. All scans were performed during the same time of the day, between 11:00-12:00, to minimize the possibility of CEDI changes attributable to diurnal CEDI fluctuations(6). Routine examinations and OCT measurements were repeated at 24 h, 72 h, 2 weeks, 4 weeks, and 12 weeks following the application of YAG capsulotomy.

SURGICAL TECHNIQUE

YAG laser capsulotomy was performed at least 3 months after surgery. Patients were treated with minimal energy and the minimal count of shots to provide sufficient capsule clarity, and a full ophthalmological examination was conducted for all patients. Pupil dilatation was provided with 1% tropicamide instillation before capsulotomy. Topical 0.5% proparacaine hydrochloride was used for corneal anesthesia. The biomicroscope was set to observe the posterior capsule after implantation of the capsulotomy lens to the eye. Capsulotomy was performed using a Tango YAG laser system (Ellex, Adelaide, Australia). The number of laser shots and shot energy were recorded. A cross or circular technique was performed according to the surgeon’s preference to obtain a capsulotomy of approximately 4 mm. After the procedure, 5 mg/mL of prednisolone phosphate four times a day was applied to the treated eye for 2 weeks.

STATISTICAL ANALYSIS

All statistical analyses were performed using SPSS for Windows version 22.0 (SPSS, Inc, Chicago, IL, USA). Continuous variables were presented as mean ± standard deviation. Pearson’s chi-square test was used to assess qualitative variables. Normal distribution was evaluated by using the Kolmogorov-Smirnov test. Homogeneity of variance was tested using Levene’s test. For parametric statistics, normally distributed data were analyzed using the repeated measures ANOVA test. When a significant result was obtained, Bonferroni’s correction was used for post-hoc comparisons. A p value <0.05 was considered statistically significant.

RESULTS

Overall, 28 patients (13 males and 15 females) were included in the study. The mean age was 63.17 ± 9.67 years (age range, 42-80 years). The mean axial length (AL) was 23.23 ± 0.88 mm. The mean time passed from cataract surgery to YAG capsulotomy was 47.46 ± 16.98 months. The mean application of YAG power was 41.93 ± (14-83) mJ. The mean three month spherical equivalent was measured as -0.55 ± 1.49 diopter (D).

Table 1 shows that the central macular volume (CMV) value was 0.2100 ± 0.01 mm³ at baseline and 0.2139 ± 0.001 mm³ 12 weeks after YAG capsulotomy, but this difference and the other observed differences during the follow-up measurements were not found to be statistically significant. Similarly, as demonstrated in table 1 and figure 1, CEDI was 275.85 ± 74.78 µm at baseline and 278.67 ± 76.20 µm 12 weeks after YAG capsulotomy. Changes in CEDI results were not statistically significant (p=0.198). Similarly, as shown in table 1 and figure 2, the central macular thickness (CMT) before YAG capsulotomy was 272.14 ± 25.76 µm and 273 ± 26.63 µm 12 weeks after YAG capsulotomy. These findings were not statistically significant either (p=0.05).

Table 1 shows that the central macular volume (CMV) value was 0.2100 ± 0.01 mm³ at baseline and 0.2139 ± 0.001 mm³ 12 weeks after YAG. Changes in CMV values were also found statistically insignificant (p=0.115). Table 1 demonstrates a total macular volume (TMV) value of 8.53 ± 0.33 mm³ before YAG capsulotomy and 8.54 ± 0.34 mm³ 12 weeks after YAG capsulotomy; however, again the displayed changes with regard to TMV values were statistically insignificant (p=0.245).

Figure 3 and table 1 show the RNLF changes between baseline (99.89 ± 7.61 µm) and 12 weeks after YAG capsulotomy (99.60 ± 8.35 µm); no statistical significance (P=0.130) was observed through the follow-up.

Table 1. Most important findings observed before and after neodymium yttrium aluminium garnet capsulotomy (YAG)

<table>
<thead>
<tr>
<th></th>
<th>TO mmHg</th>
<th>CMT µm</th>
<th>CEDI µm</th>
<th>GnRNFL µm</th>
<th>CMV mm³</th>
<th>TMV mm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>B YAG</td>
<td>14.25 ± 2.74</td>
<td>272.14 ± 25.76</td>
<td>275.85 ± 74.78</td>
<td>99.89 ± 7.61</td>
<td>0.2100 ± 0.01</td>
<td>8.53 ± 0.33</td>
</tr>
<tr>
<td>A 24 h</td>
<td>14.32 ± 3.07</td>
<td>266.53 ± 26.47</td>
<td>278.46 ± 83.46</td>
<td>98.50 ± 8.62</td>
<td>0.2111 ± 0.01</td>
<td>8.52 ± 0.32</td>
</tr>
<tr>
<td>A 72 h</td>
<td>15.03 ± 3.21</td>
<td>269.14 ± 27.20</td>
<td>283.39 ± 82.84</td>
<td>98.14 ± 8.69</td>
<td>0.2100 ± 0.01</td>
<td>8.52 ± 0.33</td>
</tr>
<tr>
<td>A 2 w</td>
<td>14.82 ± 3.07</td>
<td>272.17 ± 26.97</td>
<td>280.00 ± 77.16</td>
<td>99.60 ± 8.39</td>
<td>0.2100 ± 0.03</td>
<td>8.53 ± 0.33</td>
</tr>
<tr>
<td>A 4 w</td>
<td>15.01 ± 3.10</td>
<td>270.91 ± 26.79</td>
<td>278.37 ± 76.95</td>
<td>99.60 ± 8.39</td>
<td>0.2136 ± 0.01</td>
<td>8.53 ± 0.33</td>
</tr>
<tr>
<td>A 12 w</td>
<td>15.21 ± 3.22</td>
<td>273.00 ± 26.63</td>
<td>278.67 ± 76.20</td>
<td>99.60 ± 8.35</td>
<td>0.2139 ± 0.01</td>
<td>8.54 ± 0.34</td>
</tr>
</tbody>
</table>

B= before; A= after; CMT= central macular thickness; CEDI= central subfoveal EDI; GnRNFL= average retinal nerve fiber layer; CMV= central macular volume; TMV= total macular volume
DISCUSSION

YAG laser capsulotomy is the standard treatment for PCO, which is seen generally between 20%-50% after 5 years of the surgery\(^6\)-\(^9\). Although it is a reliable method, complications such as refraction changes, IOP changes, IOL injury, IOL dislocation, macular edema, iridocyclitis, vitritis, vitreous hemorrhage, and retinal detachment have been reported after YAG laser capsulotomy\(^10\)-\(^13\).

Post-YAG capsulotomy retinal complications generally tend to be revealed later and have more risks in terms of functional loss. A previous study\(^10\) evaluated YAG-associated complications and found a ruptured anterior hyaloid rate of 7.5%, a retinal tear rate of 4.1%, a retinal detachment rate of 2.5% and a macular edema rate of 4.1%. CME, in particular, which is commonly observed after surgery (observed clinically at a 1%-level post-phaco) is the most delicate problem and may present as disturbed vision after YAG capsulotomy\(^13\). It is most commonly observed between 8 and 12 weeks after YAG. IOP changes, vitreous fluctuations, degradation products, and inflammation after YAG can result in disruption of the blood retinal barrier and retinal detachment\(^14\)-\(^15\). The inflammation and damage caused by particles which were revealed besides the impact of inflammation generally made by the process can create a response in the retina. All these factors can result in increased thickness or a decrease in the thickness of posterior structures like the retina and choroid.

In one study, the authors stated that they did not detect any meaningful increase in OCT measurements after laser capsulotomy for patients in whom the authors measured the thickness of the central macula with preoperative OCT\(^16\). In our study, the measurements were repeated 24 h and 72 h after application to closely follow any potential inflammatory processes, and at the 2nd and 4th week after discontinuation of drug administration, and because of the possibility of disruption of the blood retinal barrier, the measurements were repeated at the 12th week in which week CME is observed most frequently. On the first day following YAG capsulotomy, an increase was observed in CMT. This rise had a tendency to recover on the 3rd day, and the values at week 2, week 4, and week 12, were similar to those observed on the first day. No statistically significant difference was observed during all these changes. Probably, a slight vasoconstriction occurred in the retinal vessels, and by that time, because no complication had developed, there was recovery.

Cystoid macular edema was not observed in any of the 28 patients, and no statistically significant difference was observed in CME measurements in terms of macular thickness and macular volume. Similarly, a study\(^17\) monitoring various parameters after YAG capsulotomy in 31 eyes, reported that the change in arc macular thickness was not statistically significant. Another similarity to this study was that no complications developed over the follow-up period, which had an equal length. Therefore, this demonstrates that the follow-up of complicated cases would be more significant during the process. The reason for preferring uncomplicated cases in particular is to enable normal results to be monitored. No statistically significant change in macular thickness was observed in this study during the follow-up of 3 months. Furthermore, for this period, the procedure is found reliable for uncomplicated cases. The follow-up of 3 months may be too short for these cases.

In a study on the comparison of post-YAG capsulotomy size and macular thickness, it was stated that a rise in IOP could be related to a large capsulotomy but not a change in macular thickness\(^6\). Similarly, in a study performed by reviewing the applied force and complication, the authors\(^4\) found that CMT change was significant in cases where >80 mj was applied, but insignificant when a force <80 mj was applied. Here if we consider that the necessary dose is applied to open the capsule, this means that a higher dose results in a more rigid and thick capsule and the release of more capsular degradation products. In our study, no significant thickness or IOP change was observed. The average dose applied in our study was 40.97 (10-80) mj.
and could be considered equivalent to that applied in the group in which <80 mj was used. In this regard, the results of our study overlapped with that study. The long-term effect of the reactions that occur in the early days after YAG capsulotomy vary depending on the distortion of the blood retinal barrier while it recovers from inflammation; it is unlikely that they could be independent there of in the process.

The choroid, being responsible for 85% of ocular perfusion, is sensitive to IOP changes. Increased IOP following YAG is the most common complication; despite prophylactic treatment its incidence was observed as between 15%-30% in some studies16,18,19. The short- and long-term results are unclear in studies15,19-21 examining IOP changes after YAG capsulotomy. Whether or not the choroid is influenced as a result of pressure fluctuations after YAG capsulotomy should, therefore, be subject to scrutiny. Moreover, there is a possibility that the inflammation in the first days after the procedure might bring about a change in choroidal tissues. Various changes in the choroid are also probable in retinal complications (which are seen at a later stage).

For various diseases and conditions, the thickness of the choroid, which has an important role in the nutrition of the inner layers of the retina, have been measured and published22-30. To the best of our knowledge, no study has been performed to investigate choroidal thickness after YAG capsulotomy. Our purpose here was to reveal whether there is a subclinical change. The causes of retinal complications observed post-YAG capsulotomy, particularly of CME, are commonly revealed as capsular degradation products and a deteriorated blood retinal barrier. Considering the data of our study, no significant choroidal thickness was observed at either 24 or 72 h or at follow-up 3 months after application. Although a slight thickening was observed in the early stages of the process, this thickening had a tendency to diminish over time to the level observed on the first day. A slight rise in thickness particularly in the early days of application could suggest a mild subclinical inflammation (although not statistically significant). Investigating this in detail would necessitate studies with larger sample sizes. The follow-up of changes could be more significant in cases where scanning of macular thickness was made, especially in cases where CME development occurred.

In the analysis of RNFL, a change in average thickness (similar to retinal thickness and volume) was observed with a slight decrease initially in measurements at 4 and 12 weeks; thickness levels reached a thickness level, which was similar to the initial results. The difference between the results were not statistically significant. No significant change in IOP was observed in any case; this may be a result of pressure fluctuations after YAG capsulotomy. Although not statistically significant, the parameters indicate that the application triggers a mild inflammation. To conclude, YAG capsulotomy is a safe and effective method. However, the smallest dose application and close follow-up would increase the reliability of the application.

REFERENCES