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A Prospective Pilot Study Comparing the Retinal Layer Effects of Two Techniques for Nd: Yag Laser Posterior Capsulotomy

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Authors' contributions

This work was carried out in collaboration between all authors. Authors Reşat Duman and Rahmi Duman designed the study. Authors Reşat Duman, MCS and EÇ performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors Reşat Duman and SB managed the analyses of the study. Authors Reşat Duman and SB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To compare the effects of cruciate and circular Neodymium: yttrium-aluminum-garnet (Nd: YAG) laser posterior capsulotomy techniques on the thickness of retinal layers measured by spectral domain optical coherence tomography (SD-OCT).
Study Design: A prospective cohort, clinical study
Setting Single surgery, Afyon Kocatepe University Hospital, TR.
Materials and Methods: 28 pseudophakic patients with the posterior capsule opacification were included in this prospective pilot study. Age- and sex-matched 2 groups were formed and either cruciate or circular technique for Nd: YAG laser posterior capsulotomy was applied to each group.

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All patients were examined 1 week and 1 month after the capsulotomy. Best corrected visual acuity (BCVA), intraocular pressure (IOP) and retinal layer thickness measurements by OCT were recorded precapsulotomy and at the following visits. Mean shot energy and number, total laser energy, IOP, BCVA and OCT findings were compared between 2 groups.

Results: Despite the higher number of laser shots and total laser energy applied in circular technique group, no significant difference of central macular thicknesses at 1000, 3000, and 6000 mm was observed between two techniques.

Conclusion: The cruciate technique may be suggested to be safer than the circular technique in terms of amount of used energy. The short-term effects on the retinal layers seem to be similar in both techniques.

Keywords: Nd: YAG laser; retinal layers; intraocular pressure; OCT.

1. INTRODUCTION

Posterior capsular opacification (PCO) is the most common long-term complication of cataract surgery causing a reduction in visual acuity and contrast sensitivity [1,2]. In mild PCO, it may not affect the vision of patients initially [2]. The incidence of PCO was reported to be 8.7% to 50% within the next 5 years after cataract surgery [3,4]. The Neodymium: yttrium-aluminum-garnet (Nd: YAG) capsulotomy is accepted as standard treatment for PCO and has been found to be safe and effective [5,6]. Nd: YAG laser capsulotomy procedure produce a central opening in the opacified posterior capsule [4]. Several techniques with various advantages and disadvantages including cruciate, circular, horseshoe, or spiral techniques have been described for nd: yag laser treatment. The cruciate and the circular techniques are the most commonly used nd: yag laser techniques in ophthalmology practice [7,8]. according to a survey by gomaa et al., 47% of the ophthalmologists apply the nd: yag laser procedure in a cruciate pattern, 27.3% use a circular technique, 23.5% use both techniques and 2.3% prefer other techniques [7].

Most common complications after ophthalmic laser capsulotomy are transient intraocular pressure (iop) increase, intraocular lens damage, iritis, vitritis and uveitis. Rarely, retinal complications such as cystoid macular edema (cme), retinal detachment, macular holes have been reported after nd: yag laser capsulotomy [9-12].

Previously several studies compared the various aspects of different techniques, however, to the best of our knowledge, this is the first study in the literature evaluating the effects of cruciate and circular techniques on the thickness of retinal layers by using spectral domain optical coherence tomography (sd-oct).

2. MATERIALS AND METHODS

2.1 Patients

This is a prospective non randomized comparative study with an institutional review board approval. Between April and August 2017, 28 pseudophakic patients who fulfilled the inclusion criteria and provided written informed consent for the analyses were included in the study. 1. Age of 45-75 years; 2. Having uncomplicated cataract surgery at least 6 months ago; 3. Having best corrected visual acuity (BCVA) of 0.1 Snellen or; 4. Having membranous type PCO were described as inclusion criteria of the study. In addition, patients with any other ocular or systemic disease, history of smoking, alcohol intake or taking any medication including systemic vasoactive drugs within the last 3 months were excluded from the study.

Patients were divided into 2 similar groups in terms of age and gender. Cruciate or circular capsulotomy techniques were applied to each group. BCVA(based on Snellen chart), IOP (measured by Goldmann applanation tonometry) and retinal layer thickness measurements by OCT were recorded before and 2 days, 1 week and 1 month after the laser capsulotomy. Mean shot number and energy, the total energy used, IOP, BCVA changes, and OCT findings were compared between groups.

2.2 Nd: YAG Laser Posterior Capsulotomy Procedure

Before the procedure, sufficient mydriasis was made by tropicamide (1%). After topical anesthesia with 0.5% proparaine hydrochloride, Abraham capsulotomy contact lens was used to stabilize bulbus and focus the laser. Each procedure was performed by the same surgeon by using Laserex Integre (Australia, ELLEX medical).

In cruciate technique group, the first pulsed laser shots were given horizontally in visual axis and then expanded in the vertical axis to create an appropriate opening (3 mm) in the posterior capsule. In circular technique group, the shots were given in circular fashion on the tension lines to create an appropriate opening (3 mm) in the posterior capsule. A capsulotomy was initiated at the optic axis area with 2 different techniques with the lowest energy starting from 0.7 mJ. All patients were prophylactically treated with brimonidine tartrate for 2 days to prevent a post-procedural IOP increase.

All patients received a full detailed ophthalmologic examination including ophthalmoscopic evaluation and tests for visual acuity, autorefraction, and intraocular pressure pre-and post-procedure. In addition, retinal OCT imagings were performed with SD-OCT. Segmentation of the retinal layers from each SD-OCT scan was performed using the inbuilt Spectralis mapping software [the Heidelberg Eye Explorer (version 6.0c)] as previously defined in the Early Treatment Diabetic Retinopathy Study (ETDRS).

Spectralis segmentation software was used to obtain the following thickness measurements: total retinal thickness (Retina); retinal nerve fiber layer (RNFL); ganglion cell layer (GCL); inner plexiform layer (IPL); inner nuclear layer (INL); outer plexiform layer (OPL); outer nuclear layer (ONL); retinal pigment epithelium (RPE) (Fig 1). In addition, thickness of inner retinal layers (IRL) and outer retinal layers (ORL) was evaluated by the Automatic Segmentation tool of the Posterior Pole scan. The thickness of all layers within the central ETDRS zone of 1000 and 3000 mm and 6000 mm diameter was also recorded for each scan (Fig 2).

2.3 Statistical Analysis

Statistical analyses were performed using SPSS software (version 16; SPSS Inc., Chicago, IL, USA). Distributions of normality of the parameters were checked with the Kolmogorov-Smirnov test. Differences between groups were

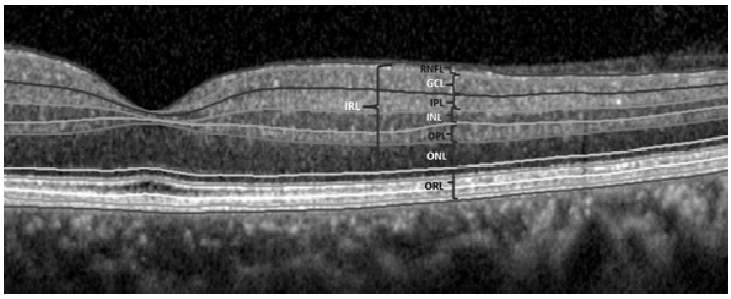

Fig. 1. Spectral segmentation software was used to obtain the following thickness measurements: total retinal thickness (Retina); retinal nerve fiber layer (RNFL); ganglion cell layer (GCL); inner plexiform layer (IPL); inner nuclear layer (INL); outer plexiform layer (OPL); outer nuclear layer (ONL); retinal pigment epithelium (RPE)

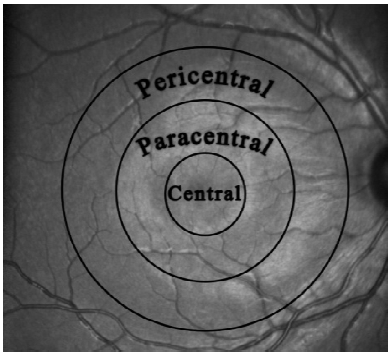

Fig. 2. The thickness of all layers within the central ETDRS zone of 1000 and 3000 mm and 6000 mm diameter was also recorded for each scan

compared using an unpaired t-test or analysis of variance (ANOVA) for normally distributed variables and a Mann-Whitney U test or Kruskal-Wallis test for non-normally distributed variables. Bivariate correlations were evaluated using the Pearson or Spearman rank correlation coefficient for non-normally distributed variables. p values < 0.05 were considered statistically significant.

3. RESULTS

In this study participants were divided into 2 age- and sex-matched groups: Group 1 including 14 subjects (Male/female:7 /7 female, mean age: 58.64 ± 8.44) treated with the cruciate technique and group 2 including 14 subjects (Male/female: 7/7, mean age: 60.92 ± 6.36) treated with the circular technique. There was no significant difference observed for age between two groups (p= 0,426). Demographical data was shown in Table 1.

The mean pre-and post-procedure IOP did not significantly increase or decrease at all visits in two groups (15.8 ± 2.3 mm Hg at 1st week and 13.5±1.3 mm Hg at 1 month in cruciate group p= 0,291 vs.15.0 ± 1.9 mm Hg 1st week and 13.7 ± 1.7 mm Hg at 1 month in circular group, p= 0,304). We found that the mean pre-and post-procedure BCVA for snellen significant improvement at all visits in two groups (pre-procedure 0.42 ± 0.12, 0.78 ± 0.12 at 1st week and 0.85 ± 0.12 at 1 month in cruciate group p<0.000 vs. pre-procedure 0.38 ± 0.10, 0.80 ± 0.14 at 1st week and 0.87 ± 0.12 in circular group p<0.000). Clinical findings were shown in Table 2.

In cruciate and circular groups, the means for number of shots were 24.4 ± 8.7 and 33.5 ± 9.6 (p:0.01), the means for shot energy were 2.18 ± 0.44 and 2.92 ± 0.65 (p:0.02) and the means for total energy were 59.7 ± 18.28 and 105.7 ± 33.7 (p<*0.001*), respectively. All of these parameters were significantly higher in circular group. Detailed comparison of 2 groups was given in Table 3.

Despite higher shot energy and number, and total energy with the circular technique, there were no significant differences in both of 2 groups in the measurements of Retina, RNFL, GCL, IPL, INL, OPL, ONL, RPE, IRL, and ORL layer thickness in 1000, 3000, 6000 mm subfield zone, which were summarized in the Table 4.

Table 1. Demographical data

	Group-1 (Cruciate Group) n:14	**Group-2 (Circular Group) n:14**	***p***
Gender			***1***
Male	7	7	
Female	7	7	
Age (mean yrs ± std)	58.64 ± 8.44	60.92 ± 6.36	*0.426*

Table 2. Change in BCVA and IOP after the procedure

	Day 0	**Week 1**	**Month 1**	***p***
IOP (mmHg, mean ± std)				
Group 1	13.4 ± 2.4	15.8 ± 2.3	13.5 ± 1.3	*0,291*
Group 2	13.0 ± 2.1	15.0 ± 1.9	13.7 ± 1.7	*0,304*
BCVA (Snellen, mean ± std)				
Group 1	0.42 ± 0.12	0.78 ± 0.12	0.85 ± 0.12	<0.0001
Group 2	0.38 ± 0.10	0.80 ± 0.14	0.87 ± 0.12	<0.0001

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Table 3. The comparison of the mean number of shots, mean shot energy and total energy in 2 group

	Cruciate group	**Circular group**	**P value**
Mean number of shots	24.4 ± 8.7 (12-50)	33.5±9.6 (18-60)	0.01
Mean spot energy (Mj)	2.18 ± 0.44 (0.7-1.5)	2.92 ± 0.65 (0.7-1.5)	0.02
Mean total energy (Mj)	59.7 ± 18.28 (30-150)	105.7 ± 33.7 (50-250)	0.00

Table 4. Mean layers thickness as measured by heidelberg SD-OCT for crusiat and circular gruops

	Central ring (mean±sd)								*Paracentral ring (mean±sd)*								*Pericentral ring (mean±sd)*							
	Crusiat				**Circular**				**Crusiat**				**Circular**				**Crusiat**				**Circular**			
	Origin (0)	**First week**	**First month**	**P**	**Origin**	**First week**	**First month**	**P**	**Origin (0)**	**First week**	**First month**	**P**	**Origin**	**First week**	**First month**	**P**	**Origin (0)**	**First week**	**First month**	**P**	**Origin**	**FIRST WEEK**	**FIRST MONTH**	**P**
RETINA	259,00± 16,63	258,71± 18,77	257,57± 17,17	W-0: 0,893 M-0: 0,390	264,71± 13,19	269,28± 13,91	267,14± 13,43	W-0: 0,009 M-0: 0,055	319,46± 20,56	320,03± 20,73	317,42± 21,40	W-0: 0,231 M-0: 0,037	327,07± 9,41	328,21± 9,32	326,60± 10,03	W-0: 0,255 M-0: 0,632	289,50± 12,34	289,54± 11,93	287,12± 12,47	W-0: 0,960 M-0: 0,072	285,35± 9,98	284,67± 12,70	283,39± 10,76	W-0: 0,622 M-0: 0,109
RNFL	11,71± 1,38	12,014± 2,60	12,00± 1,15	W-0: 0,629 M-0: 0,359	11,42± 1,81	12,42± 1,51	12,28± 2,28	W-0: 0,156 M-0: 0,407	20,53± 1,59	21,07± 1,78	20,25± 1,49	W-0: 0,115 M-0: 0,291	20,85± 2,16	20,53± 4,35	21,32± 2,27	W-0: 0,799 M-0: 0,088	33,93± 4,41	35,25± 3,51	33,31± 5,24	W-0: 0,291 M-0: 0,342	31,45± 6,59	34,91± 3,93	34,66± 3,47	W-0: 0,119 M-0: 0,152
GCL	12,57± 4,57	13,42± 4,64	13,28± 4,60	W-0: 0,017 M-0: 0,334	14,57± 4,92	15,28± 6,12	13,57± 2,01	W-0: 0,441 M-0: 0,062	44,57± 6,88	44,14± 6,69	44,28± 6,34	W-0: 0,537 M-0: 0,497	46,28± 9,76	45,10± 12,14	47,75± 5,90	W-0: 0,771 M-0: 0,481	34,12± 0,63	36,00± 2,79	34,68± 3,94	W-0: 0,321 M-0: 0,808	34,62± 4,33	33,50± 4,28	33,62± 3,83	W-0: 0,597 M-0: 0,653
IPL	20,00± 4,16	19,28± 3,68	18,42± 2,82	W-0: 0,582 M-0: 0,199	19,00± 2,82	19,57± 4,11	19,71± 2,69	W-0: 0,604 M-0: 0,411	36,78± 3,78	37,46± 3,68	36,60± 3,76	W-0: 0,215 M-0: 0,739	37,42± 5,19	37,10± 7,38	38,50± 3,50	W-0: 0,900 M-0: 0,289	28,55± 2,34	28,65± 2,62	28,35± 2,73	W-0: 0,916 M-0: 0,495	26,92± 3,26	27,71± 2,72	27,64± 1,95	W-0: 0,135 M-0: 0,251
INL	20,57± 5,06	21,00± 5,19	22,28± 5,99	W-0: 0,407 M-0: 0,539	19,57± 3,95	20,42± 4,46	19,85± 3,76	W-0: 0,172 M-0: 0,673	40,89± 3,72	40,78± 4,27	41,32± 3,89	W-0: 0,901 M-0: 0,677	40,35± 4,38	37,17± 2,33	39,25± 3,88	W-0: 0,117 M-0: 0,075	35,25± 2,57	32,70± 2,48	32,85± 1,92	W-0: 0,184 M-0: 0,192	34,82± 3,98	31,53± 3,79	32,00± 4,04	W-0: 0,105 M-0: 0,156
OPL	24,00± 4,96	26,00± 6,48	23,28± 5,82	W-0: 0,312 M-0: 0,665	25,57± 8,63	26,00± 8,73	27,42± 8,59	W-0: 0,805 M-0: 0,486	31,42± 1,51	31,10± 2,83	31,75± 2,01	W-0: 0,656 M-0: 0,747	33,25± 2,85	33,46± 3,78	33,10± 2,01	W-0: 0,906 M-0: 0,823	27,20± 1,95	27,08± 1,45	26,41± 2,06	W-0: 0,695 M-0: 0,222	27,82± 1,17	27,39± 1,68	27,00± 1,62	W-0: 0,426 M-0: 0,288
ONL	90,42± 5,59	87,28± 12,59	87,71± 12,67	W-0: 0,468 M-0: 0,441	93,85± 12,03	96,71± 13,40	94,25± 13,20	W-0: 0,480 M-0: 0,892	66,89± 10,84	66,78± 10,70	64,96± 11,71	W-0: 0,911 M-0: 0,136	70,14± 11,06	76,14± 20,86	68,39± 6,14	W-0: 0,509 M-0: 0,640	52,37± 8,34	52,43± 8,20	53,43± 8,36	W-0: 0,836 M-0: 0,707	56,04± 10,42	52,66± 2,98	53,12± 4,36	W-0: 0,422 M-0: 0,448
RPE	15,14± 1,21	15,57± 2,14	15,57± 3,82	W-0: 0,448 M-0: 0,803	14,85± 1,34	15,71± 1,49	15,14± 2,26	W-0: 0,308 M-0: 0,689	14,14± 0,95	13,67± 1,21	13,17± 1,03	W-0: 0,174 M-0: 0,028	13,42± 1,04	14,10±0,59	13,92± 0,70	W-0: 0,112 M-0: 0,167	12,30± 0,75	12,20± 0,54	12,10± 0,48	W-0: 0,717 M-0: 0,512	12,60± 0,87	12,92± 0,57	12,96± 0,61	W-0: 0,362 M-0: 0,182
IRL	176,42± 16,08	177,57± 17,03	175,71± 16,61	W-0: 0,462 M-0: 0,634	182,85± 12,42	186,14± 13,63	184,14± 13,37	W-0: 0,155 M-0: 0,440	241,07± 19,58	241,53± 20,28	239,07± 20,21	W-0: 0,424 M-0: 0,030	248,50± 10,22	249,28± 9,24	248,17± 10,30	W-0: 0,535 M-0: 0,722	212,00± 15,47	212,75± 14,57	209,25± 15,95	W-0: 0,238 M-0: 0,131	208,12± 11,13	207,75± 13,60	206,83± 11,90	W-0: 0,885 M-0: 0,205
ORL	82,71± 4,11	81,28± 3,63	82,14± 4,77	W-0: 0,220 M-0: 0,643	82,00± 2,76	83,42± 3,40	83,00± 3,05	W-0: 0,334 M-0: 0,480	78,64± 1,10	78,53± 1,41	78,55± 1,12	W-0: 0,702 M-0: 0,362	76,39± 6,99	79,42± 1,90	78,46± 1,57	W-0: 0,317 M-0: 0,487	76,35± 1,39	76,40± 1,46	76,65± 1,39	W-0: 0,910 M-0: 0,235	77,60± 1,34	77,11± 1,67	76,50± 1,27	W-0: 0,342 M-0: 0,087

O: ORIGIN W: FIRST WEEK, M: FIRST MONTH

In both groups, visual acuity improved and no CME was observed after the procedure, and no significant change in retinal layer thickness was observed in postoperative OCT analysis compared to preoperative measurements, which were given in Table 4.

4. DISCUSSION

In the present study, we aimed to compare the effects on retinal layers of cruciate and circular Nd: YAG laser posterior capsulotomy techniques performed for the treatment of PCO. The results showed no significant difference in retinal layer thicknesses between two groups despite higher number of shots and more energy applied in circular technique group.

One of the factors which might influence the results was the type of PCO. As there are various types of PCO (including membranous, Elschnig pearls and the ring of Sommerring) which may significantly influence the total amount of energy and the number of shots during laser procedure [13]. To rule out the possible influence of PCO type, only patients with membranous PCO were included in the study, which may also explain the reason for limited number of study patients.

In some recent studies, capsulotomy size has been suggested to be associated with the total amount of laser energy used and postoperative complications [13-15]. It has been suggested that the diameter of the capsulotomy may cause a negative effect on the position of the intraocular lens. Karahan E et al. and Findl et al. reported that large capsulotomy diameters caused a hyperopic shift, however, Thornval et al. could not observe this effect in their studies [6,13,16]. In the present study, we made an opening of 3 mm in both techniques to rule out the influence of capsulotomy size on postoperative outcomes.

In several previous studies, postoperative increase in IOP measurements was reported in 0.6-30% of patients after laser capsulotomy [5,17,18]. Factors effecting IOP rise are controversial. Karahan E et al. demonstrated that the large capsulotomy size was associated with rising in IOP [13]. Literature data on the association between capsulotomy technique and IOP results are lacking. In the present study, IOP values were lower in postoperative measurements in both groups. In addition, we did not find any significant IOP difference between cruciate and circular technique groups despite significant difference in the amount of energy used. Postoperative prophylactic treatment with brimonidine in all patients in our study might cause decreased IOP levels postoperatively in both groups. The use of the prophylactic treatment might have masked effect of both techniques on IOP changes.

Severe retinal complications such as retinal tear, retinal detachment and CME can be detected after Nd: YAG laser capsulotomy. Steinert et al. reported a rate of 0.89% for CME [15]. Although it's a contraversial issue, some authors suggested that higher laser energy might be associated with increased risk of CME. Ari S et al. showed that central macular thickness change was significant in cases whom > 80 mj was applied, but insignificant when a force of < 80 mj was applied [14]. In our study the means of applied total energies were 59.7 ± 18.28 mj in cruciate group and 105.7 ± 33.7 mj in circular group respectively. Although the mean applied total energy was greater than 80 mj in circular group, none of the patients had CME or any other retinal complication. But the limitation in patient number might have prevented occurrence of complications.

Our study differs from other studies in that measurements are taken not only in the central macula but also in the paracentral and pericentral areas. In contrast, our study findings did not show any significant difference in macular thickness at central 1000, 3000, and 6000 mm between both capsulotomy techniques using a different amount of energy (59.7 ± 18.28 mJ vs 105.7 ± 33.7 mJ in cruciate and circular techniques respectively). Although no significant difference was observed in both of two techniques in terms of macular thickness, using circular capsulotomy technique seemed to be more riskier as it required more energy.

The small sample size and short-term follow-up period are the limitations of our study. The small sample size precludes firm conclusions, and further investigation would be required in a larger study population with longer follow-up period.

5. CONCLUSION

In conclusion, we have found that higher number of laser shots and total laser energy had been applied in circular technique group. Nevertheless, central macular thicknesses at 1000, 3000, and 6000 mm did not significantly differ between two techniques. Although the

cruciate technique may be suggested to be safer than the circular technique in terms of an amount of used energy, the short-term effects on retinal layers seem to be similar in the two techniques.

CONSENT

As per international standard or university standard written patient consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard written ethical permission has been collected and preserved by the authors**.**

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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