Comparative structural and functional outcomes of cruciate and circular YAG capsulotomy techniques

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Short title: Comparing cruciate and circular YAG capsulotomies.

Abstract:

Purpose: To compare outcomes of cruciate and circular YAG capsulotomy techniques regarding: Best corrected Visual acuity (BCVA) improvement, significant change in IOP and central macular thickness.

Methods: A prospective comparative cohort including medically free patients with visually significant posterior capsular opacity who underwent uneventful cataract surgery more than 6 months ago. Divided to Group A: 110 eyes for cruciate YAG capsulotomy technique. Group B: 110 eyes for circular YAG capsulotomy technique. All patients underwent complete ophthalmological examination including BCVA, PCO examination, IOP measurement and central macular thickness (CMT)by OCT, performed before the procedure and one month afterwards. capsulotomies were done with an initial energy of 0.8 mJ and increased in increments of 0.2 mJ until a capsular opening was achieved.

Results: There was a significant higher values in total energy: 54.0(mJ) in cruciate group vs 42.5(mJ) in circular group, total number of shots in cruciate group was 14.38 vs 12.96 in circular group respectively . Both techniques improved BCVA from baseline values by LogMAR (0.64 ± 0.09, 0.64 ± 0.06 respectively to 0.13 ± 0.02, 0.14 ± 0.03 after a month,without a significant increase in IOP (16.51 vs 17.28 mmHg respectively) ,(16.09 vs 16.78mmHg) after 1 month and CMT was(258.79vs 254.65 μm respectively) at baseline and after 1 month was (257.4 vs 260.27 μm)with insignificant difference between the two groups.

Conclusion: Both techniques proved to be efficient for clearing the visual axis in PCO, but a higher Energy was needed in cruciate technique without clinical implication.

Key words: Posterior capsular opacification, YAG capsulotomy, IOP spike, OCT.

INTRODUCTION:

The development of posterior capsular opacification (PCO) is the most frequently encountered complication of cataract extraction, with its known effect on vision quality and even life quality, this could be explained by the halo effect, poor contrast sensitivity, and disruption of binocular vision[1].

Using of using neodymium-doped yttrium aluminum garnet (Nd: YAG) laser is the international proved approach to clear the visual axis and improve BCVA[2].

Although there are different techniques available for clearing the visual axis using neodymium-doped yttrium aluminum garnet (Nd: YAG) laser, such as: circular, cruciate, horseshoe & spiral, still none of them is internationally defined as the best

approach, with their variables in advantages and disadvantages[3].

In cruciate technique, a horizontal off-axis line is drawn across the center, followed by a vertical line to form a cross. While in the circular approach, the laser is fired in a radial fashion[4].

The most encountered adverse effect of Nd: YAG laser treatment is the IOP spike after the procedure[5], both IOP spike and increased macular thickness are frequent, with their severity and duration depending on the total energy employe[6].

IOP spike immediately after the procedure, reaches its peak 3–4 hours later, and then typically decline but may stay high for 24 hours in some cases. IOP usually recovers to baseline after 1 week[7].

Reduced aqueous outflow capacity by capsular debris, acute inflammatory cells, liquid vitreous, and shock-wave injury to the trabecular meshwork have all been implicated to this spike, with a greater risk in glaucomatous eyes[8].

The suggested prophylactic and therapeutic measure for this spike is beta-adrenergic antagonists such as apraclonidine, timolol, levobunolol, etc. They are given one hour prior to the procedure and once after, due to its miotic impact, pilocarpine should only be given after surgery[9].

The incidence of cystoid macular edema (CME) after Nd:YAG laser posterior capsulotomy ranges from 0.55% to 2.5%. It usually happens between 3 weeks and 11 months. It is suggested that increasing the interval between cataract surgery and laser capsulotomy reduces the risk of CME. The management of CME after YAG capsulotomy is same to that of CME after cataract extraction[10].

Follow-up by using optical coherence tomography (OCT) can precisely detect the increase in macular thickness after the procedure, even if it is not clinically detected[11].

The aim of this study is to compare outcomes of cruciate and circular YAG capsulotomy techniques regarding: Best corrected Visual acuity (BCVA) improvement, significant change in IOP and central macular thickness.

SUBJECTS AND METHODS:

A prospective comparative study was done, the participants were recruited from the Ophthalmology Outpatient clinic of the Kobry El-kobba Military Medical Complex and Ghamra military hospital, Cairo, Egypt, in the period between 3/2023 to 6/2023; including patients with visually significant posterior capsular opacity who underwent uneventful cataract surgery more than 6 months ago. Included subjects were divided into two groups: Group A: 110 eyes for cruciate YAG capsulotomy technique, and Group B: 110 eyes for circular YAG capsulotomy technique. Their age ranged 33–78 years in circular group and 39–82years in cruciate one.

We excluded patients with any systemic diseases, and macular pathology affecting visual acuity, macular thickness outside normal range at baseline (250-micron), glaucomatous patient or any history for increased intraocular pressure, diabetes, or uveitis and high myopes more than or equal 6 dioptres.

The study adhered to the declaration of Helsinki, was approved by institutional review board of the workplace (IRB: 123MC) and all patients signed an informed consent.

All subjects had full history taken, complete ophthalmological examination including Best corrected Visual acuity, PCO examination: degree, configuration, and severity of the PCO according to Shakeel, T, Gupta SD. (2019)[12]. Table. 1. IOP measurement by Goldmann's applanation tonometer. OCT macula was performed using OCT HEIDELBERG ENGINEERING, GERMANY. Only images with quality greater than 25 were included.

Table 1: Grading of posterior capsular opacification according to **Shakeel T, Gupta SD,2019**

Grade	Severity	PCO
Grade 0	None	No evidence of PCO
Grade 1	Trace	Few discrete epithelial pearls
Grade 2	Mild	Multiple discrete epithelial pearls
Grade 3	Moderate	Multiple coalescent epithelial pearls
Grade 4	Severe	Thick sheet of epithelial pearls

BCVA, OCT macula and IOP were all measured before the procedure and one month after the procedure. OCT macula was done after three months post procedure in 50% of patients and the rest dropped their follow up, so we recorded only after 1 month reading for all patients.

The same operator conducted all the Nd: YAG laser capsulotomies using topical anesthetic (benoxinate hydrochloride 0.4% in proparacaine). The ophthalmic

Nd:YAG laser was utilized in conjunction with Abraham capsulotomy contact lenses to create a posterior capsulotomy. Single bursts were fired with an initial energy of 0.8 mJ and increased in increments of 0.2 mJ until a capsular opening was achieved. Total energy was calculated by multiplying number of shots by the energy used to perform the aimed fashion. In the cruciate technique: the laser therapy began off-axis in a horizontal line along the middle, and then moved to a vertical line to complete the cross. The circular technique: a circular pattern of Nd: Yag laser therapy was used to perform a capsulotomy.

Statistics:

- Pre-coded data were processed in addition to statistically evaluated utilizing the Statistical Package of the Social Science Software (SPSS), version 21.
- Number & percentage were used for qualitative variables. Comparison between qualitative variables were made utilizing the Chi-square test, while an independent T-test was utilized to contrast quantitative variables among two groups. The ANOVA test was utilized for quantitative variables among more than two categories which are normally distributed, and Nonparametric Kruskal-Wallis & Mann-Whitney tests were used for quantitative variables which were not normally dispersed.
- P value (equals or less than 0.05) was regarded statistically significant.

RESULTS:

Our study included 220 cases which was distributed to two groups circular group 110 patients with mean age 56.8 years and cruciate group 110 patients with mean age 57.3 years., Male patients were n:48 representing 43.6% in circular group and n:52 representing 47.3% in cruciate group. There were insignificant differences among the 2 groups as regard age and sex.

There was insignificant difference between 2 groups related to time interval between cataract and laser procedure (50.1 months in circular group versus 47.7 in cruciate group respectively) with p value 0.737. Posterior capsular opacification grade was insignificantly differing between two groups. Table 2.

Table 2: Comparison among the two studied groups regarding energy used and posterior capsular opacification grade according to **Shakeel T,2019**

	Circular (n = 110)	**Cruciate (n = 110)**	**t**	**p**
Energy used (mJ)				
Min. – Max.	2.0 – 5.0	2.20 – 6.0		
Mean ± SD.	2.95 ± 0.71	4.29 ± 1.03	11.169*	<0.001*
Median (IQR)	2.90 (2.50 – 3.20)	4.0 (4.0 – 5.0)		
Posterior capsular opacification grade				
Min. – Max.	2.0 – 4.0	2.0 – 4.0		
Mean ± SD.	2.80 ± 0.78	2.94 ± 0.75	1.329	0.185
Median (IQR)	3.0 (2.0 – 3.0)	3.0 (2.0 – 3.0)		

There was a significantly higher difference in total energy and total number of shots in cruciate group than circular group as mean total energy (number of shots × single shot energy) was 42.5(mJ) in circular group vs 54.0(mJ) in cruciate group p value <0.001 and mean total number of shots was 14.38 in circular group vs 12.96 in cruciate group respectively with p value 0.003.

There was a significant higher mean Energy used in cruciate group than in circular group. Table 2

A regards functional outcome of the procedure in either technique, there was a significant improvement of best corrected visual acuity expressed by log MAR after the procedure in both groups ,yet with insignificant differences between both groups Table 3.

Table (3): Comparison among the two studied groups according to BCVA

BCVA (LogMAR)	Circular (n = 110)	Cruciate (n = 110)	t	p
Baseline				
Min. – Max.	0.07 – 0.73	0.50 – 0.72		
Mean ± SD.	0.64 ± 0.09	0.64 ± 0.06	0.331	0.741
Median (IQR)	0.64 (0.62 – 0.69)	0.63 (0.60 – 0.70)		
1 month				
Min. – Max.	0.10 – 0.21	0.10 – 0.20		
Mean ± SD.	0.13 ± 0.02	0.14 ± 0.03	1.701	0.090
Median (IQR)	0.13 (0.12 – 0.14)	0.14 (0.12 – 0.14)		
t_1 (p_1)	57.871* (<0.001*)	96.226* (<0.001*)		

t_1: Paired t-test

p_1: p value for comparing between **Baseline** and **1 month after the procedure** in each group

Regarding central macular thickness changes between basal measurement before the procedure and one month afterwards, none of the two groups had clinically significant macular edema after the procedure that needed treatment. There was an insignificant difference between both groups' readings at baseline & after 1 month Table 4.

Table 4: Comparison among the 2 studied groups according to central macular thickness by OCT

Central macular thickness (μm)	Circular (n = 110)	Cruciate (n = 110)	t	p
Baseline				
Min. – Max.	206.0 – 310.0	210.0 – 306.0		
Mean ± SD.	258.79 ± 29.06	257.4 ± 32.35	0.335	0.737
Median (IQR)	256.0 (231.0 – 277.0)	250.0 (233.0 – 275.0)		
1 month				
Min. – Max.	209.0 – 306.0	210.0 – 310.0		
Mean ± SD.	254.65 ± 28.86	260.27 ± 34.36	1.3136	0.1904
Median (IQR)	255.0 (230.0 – 280.0)	262.0 (235.0 – 280.0)		
T_1 (p_1)	1.0602 (0.2902)	0.637 (0.524)		

As regard mean intraocular pressure, there was an insignificant difference between both groups` baseline and after 1-month measures, it was 16.51 mmHg vs 17.28mmHg respectively at baseline p-value was 0.064 and after 1 month was 16.09 mmHg vs 16.78 mmHg respectively with p value 0. 051 Figure 1.

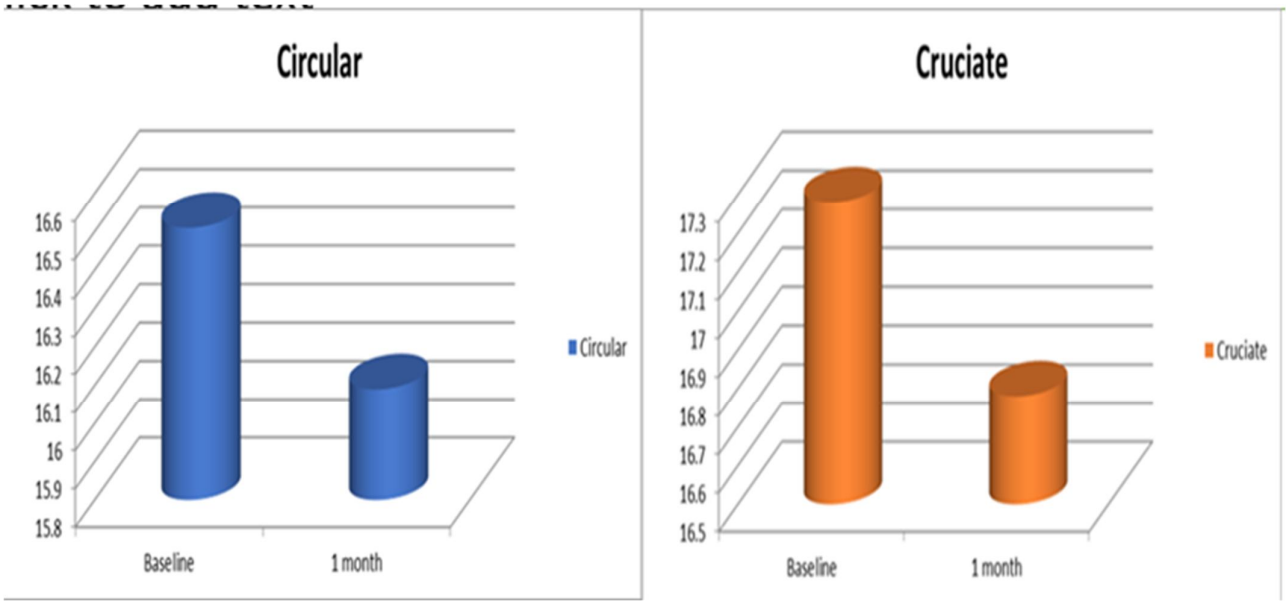

Figure 1: IOP in Circular group and Cruciate at baseline before and one month after the procedure

In correlation between energy used with central macular thickness and intraocular pressure in each group, there was a significant positive correlation between central macular thickness and energy used in circular group after 1 month with p-value 0.023. Table 5.

Table 5: Correlation between Energy used with Central macular thickness and intraocular pressure in each group

	Energy used			
	Circular		**Cruciate**	
	r	**p**	**r**	**p**
Central macular thickness				
1 month	0.217	0.023*	-0.046	0.637
IOP				
1 month	-0.061	0.524	0.019	0.844

DISCUSSION:

In our comparative study, we compared between the circular and cruciate techniques in two groups, 110 patients for each. We compared visual acuity, IOP rise and central macular thickness changes in a baseline measure and a month after the procedure with reporting any difference in energy needed in both techniques.

We found a higher significant difference in total energy, and total number of shots in cruciate group more than circular group. This comes in agreement with Aboelmaged et al. (2018)[13] and Kim et al, (2018)[14], who found that the modified round pattern group required a significantly higher total amount of energy as well as a greater number of shots in order to successfully complete the circular pattern.

Supporting our results, Li et al, (2020)[15] who demonstrated that the cruciate group received a stronger laser (2.0-2.5 mJ) than the circular group (1.5-2.0 mJ).

In contrast to our results, Rezaei et al, (2016)[16], Kara et al, (2014)[3] and El-Feky et al, (2018)[17]all found that that the mean energy & number of laser firings were significantly greater in circular shape than cruciate shape.

Regarding the functional outcome of the procedure, there was a statistically significant improvement of BCVA in both groups after the procedure but there was an insignificant variance in the BCVA at one month postoperative between the two groups. The cruciate capsulotomy group had slightly better visual acuity compared to the circular capsulotomy group, which conclude that higher energy needed in cruciate group was not up to the level that negatively affects post procedural BCVA

This comes in agreement with Kim et al, (2018)[14], Kara et al, (2014)[3] and LIN et al, (2019)[19]who found that the BCVA significantly improved in cruciate group and circular group. However, the change in BCVA was not significantly diverse among 2 groups. Also Mohamed et al, (2015)[18] who found that varied sizes and shapes of capsulotomies did not affect significantly pre procedure BCVA or post-procedure BCVA.

Regarding the structural retinal changes represented in central macular thickness by OCT, our results showed insignificant difference between pre and post procedural CMT values and also among the two groups at baseline and after 1 month. This could be correlated with the functional outcome change expressed in BCVA formerly mentioned and again clears any effect of the higher energy used in cruciate group. This comes in agreement with Kara et al, (2014)[3] and Parajuli et al, (2019)[6]

Kara et al, (2014)[3] and Parajuli et al, (2019)[6], Cetinkaya et al, (2015)[20]and Ansari et al, (2021)[21]agreed with us in finding that mean intraocular pressure differed insignificantly between the two groups at baseline and after one month of the procedure. In contrast to Mohamed et al, (2015)[17]who reported that the IOP varied significantly between pre & post-procedure in groups with Circular openings > 3.5 mm., but no difference was found between Cruciate opening and small Circular opening < 3.5 mm. Also In contrast to our results Aboelmaged et al, (2018)[13] found that Individuals with cruciate-shaped capsulotomies that had openings of under or equal to 3.5 mm (Group 1) or greater than 3.5 mm (Group 2) as well as those with circular-shaped capsulotomies that had openings of less than or equal to 3.5 mm (Group 3) or greater than 3.5 mm (Group 4) all showed statistically significant increases in IOP after Neodymium: Yttrium: Aluminum Garnet laser (pre- and post-procedural).

In conclusion, both circular and cruciate techniques proved to be efficient for clearing the visual axis in PCO and improving BCVA with no significant difference in either IOP or central macula thickness post procedure, yet A higher mean energy and number of shots were needed in cruciate technique than circular one, however, no clinical implication was found to this higher energy used.

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Data Availability: The authors declare that all data supporting the findings of this study are available within the article and its supplementary information file.

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Conflict of interest

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