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ORIGINAL PAPER

Circular YAG laser anterior capsulotomy for anterior capsule contraction syndrome

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Abstract
Purpose To evaluate circular neodymium: YAG laser incision in cases of anterior capsular contraction syndrome (ACCS) by comparing it to radial Neodymium: YAG laser incision as for efficacy and safety.
Settings Ophthalmology Department, Benha University Hospitals.
Methods The study was done on 74 eyes of 66 patients with symptomatic ACCS. Eyes were randomly allocated to one of the two groups. Group I were treated by circular YAG laser anterior capsulotomy. Group II were treated by radial YAG laser anterior capsulotomy. All cases passed a full ophthalmic examination before laser capsulotomy, 1 week, 1 month, 6 months and 12 months after laser.
Results BCVA at the 1st week and the 1st month after the capsulotomy did not show any significant difference between the two groups; however at the 3rd and 6th months, the circular group showed better visual acuity than the radial group (p 0.001 and $<$ 0.001, respectively). All post-YAG UCVA and BCVA were significantly higher than pre-YAG UCVA and BCVA in both groups. IOL decentration occurred in two cases in radial group. Circular group had significantly higher percentage of contraction relief (94.4%) than the radial group (66.7%) with p value 0.003.
Conclusion Circular Nd:YAG anterior capsulotomy is more effective and safe than radial capsulotomy in 1-year follow-up.

Keywords Anterior capsular contraction syndrome · Circular YAG anterior capsulotomy · Radial YAG anterior capsulotomy

Introduction

Continuous curvilinear capsulorhexis (CCC) is the preferred method of anterior capsulotomy among ophthalmologists [1]. The anterior capsule contraction syndrome (ACCS) is a progressive opacification, and constriction of the anterior capsule usually occurs 3–6 months after cataract surgery [2]. It was considered a rare late complication of cataract surgery, which was first reported in 1993 [3].

The pathogenesis of ACCS seems to involve anterior lens epithelial cells (LECs) myofibroblastic metaplasia [4]. Rapid ACCS has been documented in case reports of patients with advanced retinitis pigmentosa and uncharacterized rod-cone dystrophy [5–7]. The degree of ACCS varies greatly from one patient to another and also depends on the presence of conditions such as pseudoexfoliation syndrome [8],

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diabetes mellitus [9] and retinitis pigmentosa [5]. Also, the intraocular lens (IOL) material and design are important factors, as ACCS is more with silicone and plate haptics IOLs and less with hydrophobic acrylic and multiple pieces IOLs [10, 11]. Occasionally, this complication may be so severe to the extent of complete occlusion of the central capsulotomy opening by fibrous tissue [12].

ACCS can affect vision not only by opacification of the media but also by decreasing contrast sensitivity [13] and IOL tilting, deformation, dislocation [14] and even retinal detachment [2].

When established, removal of fibrosis can be done surgically using a capsulorhexis forceps to peel the fibrotic capsule [15], micro-scissors or vitrector-cut capsulotomy [16]. Recently, femtosecond laser was used to treat this condition [17, 18]. Neodymium: YAG laser is commonly used creating radial incisions in the anterior capsule to avoid more contraction [13].

The aim of this study is to compare circular neodymium: YAG laser incision to radial incisions in cases of ACCS as for efficacy and safety.

Patients and methods

A prospective double-armed study was planned and then agreed by the research ethics committee of Benha University hospitals.

The study was done on 74 eyes of 66 patients with symptomatic ACCS attending to the outpatient clinic of the Ophthalmology department, Benha University hospitals between September 2013 and April 2017. The sample size was calculated to achieve statistical power 90% with marginal error 5%.

Patients included in this study were adult, passed through uneventful cataract surgery, and had symptomatic ACCS. The exclusion criteria were complicated cataract surgery, active intraocular inflammation, past-history of ocular trauma or any other ocular surgery.

A written informed consent in Arabic was obtained from each patient according to the guidelines of the Declaration of Helsinki. Eyes were randomly allocated to one of the two groups, but randomization was directed not to have both eyes of a patient in the same group.

Group I: included 37 eyes of 37 patients who were treated by circular YAG laser anterior capsulotomy.
Group II: included 37eyes of 37 patients who were treated by radial YAG laser anterior capsulotomy.

Eight patients had bilateral ACCS, so they were represented in both groups (one eye in each group).

Patients were pretreated with brimonidine, mydriatic and anesthetic eye drops. Anterior capsulotomy was done using (Visulas YAG III, Carl Zeiss Meditec AG, Jena, Germany). Because the Nd:YAG laser is actually invisible, a helium–neon laser was used as a focusing device.

In Group I, a circular anterior capsulotomy was done just peripheral to the fibrotic rim of the ACC by pointing laser energy to the clearer part of the capsule about 2–3 mm from the rim; energy levels were recorded, energy was delivered in Q-switched mode in the form of series of pulses, and its number was recorded.

In Group II, four relaxing incisions were created from the rim of the ACO to the edge of the optic of the IOL; by pointing laser energy on the anterior capsule edge, energy levels were recorded, Q-switched mode was used, and number of pulses was recorded.

Patients were put on topical steroids prednisolone 1% four times per day and brimonidine 0.2% three times per day for 1 week after laser capsulotomy.

All cases passed a full ophthalmic examination before laser capsulotomy, 1 week, 1 month, 6 months and 12 months after laser. Examination included visual acuity by decimal chart, slit lamp examination to measure ACC and IOP measuring by applanation tonometer.

Statistical analysis of the collected data

Results were collected, tabulated and statistically analyzed with SPSS statistical package version 23.

- Student's *t* test was used for comparison of quantitative variables between two groups of normally distributed data, while Mann–Whitney's test was used for comparison of quantitative variables between two groups of non-normally distributed data.
- Paired *t* test was used to compare repeated readings of normally distributed data in the same group and Wilcoxon test for non-normally distributed ones

- Chi-square test (χ^2) was used to study association between qualitative variables. Whenever any of the expected cells were less than five, Fischer's exact test was used.
- Two-sided p value of < 0.05 was considered statistically significant.

Results

This study included 74 eyes of 66 patients; two patients did not come to follow-up visits.

Both groups were matched for age and gender without any significant difference between them. The mean age of circular group was 67.22 ± 6.66 year, and that of the radial group was 65.27 ± 5.03 year. Circular YAG group consisted of 17 males (47.2%) and 19 females (52.8%), while radial YAG group consisted of 16 males (47.4%) and 20 females (52.6%). The two groups were matched also for the pre-YAG clinical characteristics including UCVA, BCVA and IOP (Table 1).

In Group I, laser energy levels were between 1 and 1.8 mJ, energy was delivered in Q-switched mode in the form of series of pulses, and its number ranged from 12 to 18 pulses, while in Group II, laser energy levels were between 1.8 and 3.1 mJ, Q-switched mode was used, and number of pulses ranged from 20 to 32 pulses.

There was no significant difference of UCVA between the two groups at all times of follow-up after YAG capsulotomy (Table 2; Fig. 1).

BCVA at the 1st week and the 1st month after the capsulotomy did not show any significant difference between the two groups; however at the 3rd and 6th months, the circular group showed better visual acuity than the radial group (p 0.001 and < 0.001, respectively) (Table 2; Fig. 2). All post-YAG UCVA and BCVA were significantly higher than pre-YAG UCVA and BCVA in both groups.

The IOP was significantly higher in the radial group at only the 1st day after YAG (p 0.004); then, there was no significant difference between the groups at all other times of follow-up (Table 3; Fig. 3). Circular group had significantly higher percentage of contraction relief (94.4%) than the radial group (66.7%) with p value 0.003. IOL decentration occurred in two cases in radial group and in no case in circular group (Table 4).

We have eight cases represented in both groups; every case had a bilateral ACCS: one eye treated by circular YAG laser incision and the other treated by radial YAG laser incisions. We analyzed data of theses cases separately. We found no significant difference of UCVA at all times of follow-up. Eyes with circular laser showed significantly better visual acuity only in the 6 months post-YAG visit (p 0.002). The IOP was significantly higher in the eyes with radial laser at the 1st day after YAG only (p 0.003). Eyes with circular laser had significantly higher percentage of contraction relief (87.5%) than the radial group (62.5%). IOL decentration occurred in one eye with radial laser incision.

Discussion

The optic of the IOL remains in contact with inner surface of anterior capsule. The remaining capsular epithelial cells may undergo a proliferation into fibrocytes. The fibrosis occurs in the area facing the IOL and takes a circular shape [19]. Whitening and contracture of the capsulorhexis aperture were classified by Arshinoff as late complication of cataract surgery [20].

Table 1 Patients demographics and pre-YAG clinical characteristics

	Circular YAG (n = 36)	Radial YAG (n = 36)	p value
Age	67.22 ± 6.66	65.27 ± 5.03	0.16
Gender			
Male	17 (47.2)	16 (44.4)	0.81
Female	19 (52.8)	20 (55.6)	
Pre UCVA	0.15 ± 0.07	0.18 ± 0.11	0.30
Pre BCVA	0.67 ± 0.11	0.63 ± 0.10	0.17
Pre IOP	13.06 ± 1.33	12.84 ± 1.66	0.33

Table 2 UCVA and BCVA of patients; 1-year follow-up

	Circular YAG (n = 36)	Radial YAG (n = 36)	p value
Week 1			
UCVA	0.22 ± 0.08	0.26 ± 0.09	0.055
BCVA	0.76 ± 0.08	0.75 ± 0.09	0.59
Month 1			
UCVA	0.29 ± 0.08	0.30 ± 0.11	0.71
BCVA	0.85 ± 0.08	0.78 ± 0.14	0.25
Month 3			
UCVA	0.33 ± 0.09	0.30 ± 0.13	0.32
BCVA	0.91 ± 0.09	0.80 ± 0.18	0.001*
Month 6			
UCVA	0.32 ± 0.09	0.31 ± 0.13	0.47
BCVA	0.91 ± 0.09	0.78 ± 0.19	< 0.001*
Month 12			
UCVA	0.32 ± 0.07	0.31 ± 0.11	0.64
BCVA	0.91 ± 0.08	0.79 ± 0.17	< 0.001*

*Statistically significant

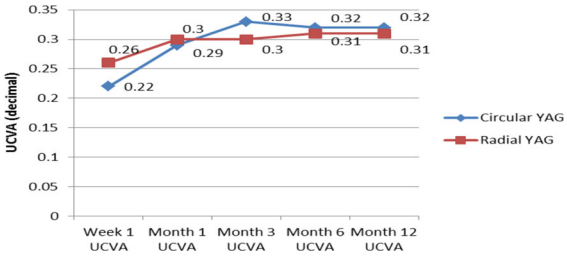

Fig. 1 UCVA of patients; 1-year follow-up

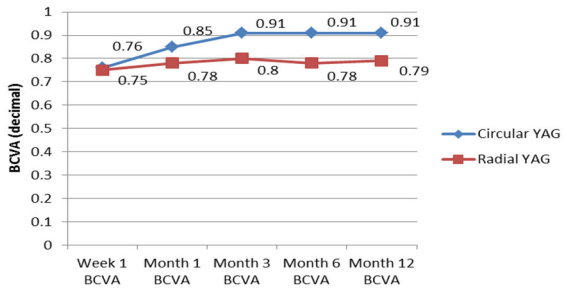

Fig. 2 BCVA of patients; 1-year follow-up

ACCS is a result of unequal centripetal and centrifugal forces on the capsular bag. Therefore, the amount of the zonular support, the IOL type and the original size of the CCC contribute to the capsular contraction syndrome, although Gonvers et al. stated that there is no relation between the CCC size and the postoperative constriction of anterior capsule [21, 22].

We aimed to investigate safety and efficacy of circular anterior capsulotomy and compare it to the radial anterior capsulotomy.

In our study, there was no significant difference between the two groups related to demographic data, preoperative both uncorrected and best corrected visual acuity. But BCVA at the 3rd postoperative month and up was better in the circular group than the radial group (p 0.001 and < 0.001, respectively); we assumed that this was due to late complications of radial anterior capsulotomy in the form of recontraction and IOL decentration. Recontraction can be explained by the inducing inflammatory reaction after treatment, which starts the production of cytokines that in turn start transformation of the residual capsular epithelial cells into myofibroblasts [23]. Recontraction may continue until causing recurrent capsular block syndrome with complete occlusion of anterior capsulotomy aperture [24]. But, no one of our patients with recontraction suffered from that.

By comparing the IOP, it was significantly higher in the radial group at only the 1st day after Nd:YAG (p 0.004). The rise of IOP following Nd:YAG laser treatment can be due to swelling of iris root or the ciliary body resulting from inflammation leading to angle closure and the precipitation of debris in the trabecular meshwork [16]. This IOP increase in radial group may be also explained by the higher laser power needed (range 1.8–3.1 mJ) and the increased number of laser pulses applied (range 20–32 pulses) in this

Table 3 IOP of patients; 1-year follow-up

	Circular YAG (n = 36)	Radial YAG (n = 36)	p value
Day 1 IOP	15.44 ± 0.96	16.50 ± 1.60	0.004*
Week 1 IOP	12.47 ± 1.19	12.92 ± 0.98	0.22
Month 1 IOP	11.95 ± 1.11	12.16 ± 1.12	0.42
Month 3 IOP	12.47 ± 1.04	12.18 ± 1.35	0.22
Month 6 IOP	12.57 ± 0.74	12.28 ± 1.11	0.30
Month 12 IOP	12.50 ± 0.89	12.31 ± 1.21	0.45

*Statistically significant

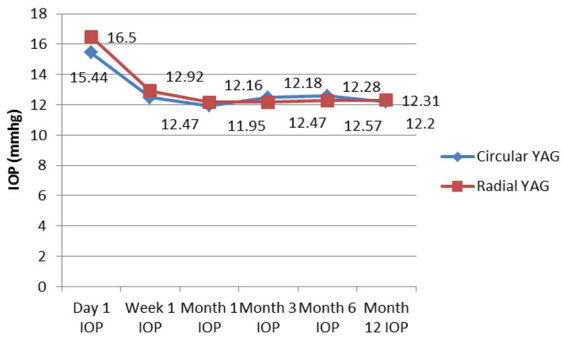

Fig. 3 IOP of patients; 1-year follow-up

Decentration occurred in two eyes treated by radial Nd:YAG anterior capsulotomy. As contraction of the anterior capsule produces centripetal forces on the ends of the IOL haptics, forcing the optic to bow posteriorly and producing pressure against the posterior capsular surface. Weak capsule offers an additional route for releasing of the upgrading tension exerted on the IOL by contracture and fibrosis of the capsule. If the capsule is compromised by Nd:YAG laser treatment [25]. We think this occurs with radial treatment because it consumes more power.

Table 4 Outcomes of anterior YAG capsulotomy

	Circular YAG (n = 36)	Radial YAG (n = 36)	p value
Contraction relief			
No	2 (5.6)	8 (22.2)	0.04*
Yes	34 (94.4)	28 (77.8)	
Recontraction			
No	34 (94.4)	32 (88.9)	0.67
Yes	2 (5.6)	4 (11.1)	
IOL decentration			
No	36 (100.0)	34 (94.4)	0.15
Yes	0 (0.0)	2 (5.6)	
IOL dislocation			
No	36 (100.0)	36 (100.0)	–
Yes	0 (0.0)	0 (0.0)	

*Statistically significant

group when compared to the other group (range 1–1.8 mJ and 12–18 pulses). In radial incisions, laser cuts through the thickened part of the capsule and so more power and number of pulses were needed while in circular incision laser cuts in the clear part of the capsule. But there was no significant difference between the groups at all other times of follow-up (1st week, 1st month, 3 months, 6 months and 1 year) as inflammation usually subsides.

The previous scenario may progress to extension of capsular tearing and IOL dislocation in the vitreous cavity [25], although this did not happen in any of our patients in both groups.

Despite these complications, Hehua Ye, Jiming Zhang and Yiyong Qian found that radial Nd:YAG anterior capsulotomy is a safe procedure to a large extent even after long-term follow-up. They retrospectively analyzed 11 eyes of 11 patients treated by Nd:YAG laser anterior capsulotomy for capsular

contraction, between November 2012 and April 2014. Data studied included BCVA, diameter of anterior capsular opening before and after Nd:YAG, and interval between surgery and capsulotomy and risk factors. The mean follow-up period was 30.1–4.5 months. At the last visit, BCVA was improved or at least stable in nine eyes (81.8%) following capsulotomy. The mean diameter of the anterior capsular opening was 5.1–0.2 mm, which was obviously larger than the diameter before laser capsulotomy (2.2–0.8 mm). No patients showed recurrence of contracture [26].

On the other hand, Craig et al. did not prefer circular Nd:YAG anterior capsulotomy and mentioned complications occurred after this treatment modality in two cases. The first was 81 years female who suffered from corneal edema as the resulting remnant was fixed to the lower corneal endothelium, while the second patient was a female aged 26 years with a free-floating remnant settled in the bottom of AC but mobile with head position, interfering with vision during reading [27, 28]. In our study, these remnants already resulted from the circular Nd:YAG but absorbed recently within 1 week with no serious complications.

Limitations of our study are the small number of patients, and the type of IOL was not taken in consideration. Daniele et al. adopted this point of view when studied the correlation between the lens epithelial cells and the IOL biomaterial. Contraction seems to occur within the first 6 weeks after surgery, and it is more aggressive with silicon IOL [29]. The ACC is subtle with acrylic IOL [30]. Also, the associated ocular co-morbidity was an effective issue to study, for example, diabetes mellitus and retinitis pigmentosa. We hope that others will pay attention to these pitfalls.

In conclusion, the two groups were matched also for the pre-YAG clinical characteristics including UCVA, BCVA and IOP. Circular Nd:YAG anterior capsulotomy is more effective and safe than radial capsulotomy in 1-year follow-up.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in this study were approved by the Benha University Research Ethics Committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in this study.

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