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Original article

Refractive Changes after Nd.YAG Laser Capsulotomy in Pseudophakic Patients

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ABSTRACT

Postoperative cataract surgery often results in posterior capsule opacification (PCO), causing low visual acuity and uniocular diplopia. Factors include patient age, lens type, surgery technique, and diseases. YAG capsulotomies, a noninvasive procedure, can cause complications like pressure elevation, IOL damage, inflammation, and retinal detachment. The study aims to evaluate the effect of Nd: YAG laser posterior capsulotomy on a patient`s refractive status. This study was conducted at Benghazi Teaching Eye Hospital in Libya. The sample consisted of patients who had anterior capsulorrhexis during cataract surgery and had anterior capsulotomies. Patients were selected based on their condition and underwent a comprehensive eye examination, including refraction, unaided visual acuity, and best-corrected visual acuity. Postoperatively, posterior capsulotomies were performed using a Nd: YAG laser. The surgical techniques involved administering a single shot of Nd: YAG laser, administering topical anesthetic agents, clearing the central posterior capsule, and applying energy levels. The mean age of 63.45 + 7.69 years, with a majority being female (63.6%) and (60.6%) right side eye. The procedure significantly impacted the participants' visual acuity(P<0.001), with changes in sphere, cylinder, and spherical equivalent measurements (<0.001). A one-month follow-up showed significant improvement in visual acuity, with a trend towards better refractive outcomes. The stability of the cylinder axis suggests a consistent correction of astigmatism post-operatively. The results demonstrate positive long-term outcomes in this study. With the average centroid being 0.52D at 26°±1.31D and 0.65D at 27°±1.23D at one month. The study found that individuals who underwent Nd: YAG posterior capsulotomy had better vision, with refraction changes frequently leading to a hyperopic shift.

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INTRODUCTION

Posterior capsule opacification [PCO] is one of the most frequent long-term postoperative complications following cataract surgery. Uniocular diplopia, contrast sensitivity, and reduced visual acuity are just a few of the issues brought on by PCO. The surviving lens epithelial cells are the primary cause of PCO. These cells multiply and move into the region between the posterior capsule and intraocular lens in the optic axis. After surgery, the incidence of PCO was 11.8% after one year, 20.7% at three years, and 28.4% at five years. The patient's age, the kind of intraocular lens [IOL], the surgical method, and any systemic or ocular diseases are some of the factors linked to PCO. For instance, compared to elderly patients, the PCO rate is higher in pediatric or young individuals. The incidence of PCO development rises in patients with uveitis or diabetes mellitus. Reduced rates of PCO have been observed recently as a result of the development of contemporary phacoemulsification technology and the introduction of sharp-edge optic IOL [1–4]

The early 1980s saw the development of Yttrium Aluminum Garnett [YAG] capsulotomies by Drs. Aron-Rosa and Fankhauser. With a success rate of over 95%, posterior capsulotomy utilizing the Neodymium-Doped Yttrium Aluminum Garnett [Nd: YAG] laser is a comparatively benign operation used to treat posterior capsular opacification. In a laser capsulotomy, a small circular opening in the visual axis is created by applying a series of focal ablations in the posterior capsule using a quick-pulsed Nd: YAG laser [5].

Although this surgery is successful, there are several risks associated with it, including increased intraocular pressure [IOP] after the procedure, damage to the IOL, IOL movement and dislocation, inflammation, cystoid macular edema, and retinal detachment [6,7]. It is still challenging to prove that a refraction change was observed in some patients following posterior capsulotomy with an Nd: YAG laser. At a mean of 16 months following Nd: YAG laser posterior capsulotomy, Petesern et al. [8] reported four occurrences of posterior silicone haptic IOL displacement. IOL movement following laser treatment has been shown in a variety of ways by several research; Findl et al. found hyperopic shift and rearward IOL movement [9].

There is debate over the impact of capsulotomy size on refractive status following Nd: YAG laser surgery. Research has indicated that a larger capsulotomy size is linked to more posterior IOL movement [9,10].

A large capsulotomy size could result in a hyperopic shift. Nonetheless, a study found that patients with capsulotomy sizes less than 4 mm experienced a refractive change of 0.38 diopter, and patients with sizes equal to or more than 4 mm experienced a change of 0.22 diopter [11]. Our study aims to evaluate the effect of Nd: YAG laser posterior capsulotomy on a patient`s refractive status.

METHODS

Study design

A prospective, interventional study was conducted in 2024 on patients diagnosed with posterior capsular cataracts attended and sought routine eye examinations at Benghazi Teaching Eye Hospital in Benghazi, Libya. The research ethics committee approved the trial, and all patients provided written informed consent before interventions, by the Declaration of Helsinki.

Inclusion and exclusion criteria

Posterior capsular opacification in patients with acrylic posterior chamber [PC] IOL following uncomplicated Cataract surgery were included. Patients who had anterior capsulorrhexis [during cataract surgery], in the bag IOL were alos selected. While, patients were excluded those with potential complications for cataract surgery include complications during cataract surgery or postoperative period, sulcus IOL implantation, glaucoma, corneal or retinal disease, ocular inflammation, toric or multifocal IOL implantation, previous laser treatments, ocular trauma, or surgery during follow-up, and colonies of Propionibacterium acnes on the IOL.

Data collection and ophthalmic examination

All patients will get a full eye examination that includes refraction, unaided visual acuity [UAVA] best corrected visual acuity [BCVA], slit-lamp biomicroscopy, and intraocular pressure measurement using Goldman tonometry. Dilated fundus examination.

The posterior capsulotomies will be done in a single session using a Nd: YAG laser. The refraction power was measured using a Topcon KR-800 auto-refractor [Topcon Corp, Nagoya, Japan]. The spherical equivalent refractive error [SE] values were determined as the sum of the sphere and half the cylindrical power. All measures were taken three times [before, one week, and one month after YAG]. Visual acuity [VA] was assessed using an office-based Snellen system. The VA values were converted to decimal units for statistical purposes. Flat keratometry [K1] and steep keratometry [K2] were used to discriminate between corneal and lenticular causes of astigmatism.

Surgical techniques of Nd: YAG laser capsulotomy

Before dilatation, a single shot of [Nd: YAG] laser was used to center the visual axis. Before the surgery, pupils were dilated with 1% tropicamide and 2.5% phenylephrine. Benoxinate hydrochloride 0.4% sterile ophthalmic solution was used as a topical anesthetic agent. To increase power density at the posterior capsule level, a typical contact lens was employed, and laser energy was used to remove a circular portion of the central posterior capsule of roughly 4.0 to 4.5 mm in diameter. Energy levels ranging from 2.5 to 3.5 mJ were applied to the capsule. In each eye, the Nd: YAG laser was defocused to the posterior by 0.50 mm. Each patient's energy level, total spot count, and total energy usage were recorded. Following capsulotomy, prednisolone acetate 1% four times daily and brimonidine tartrate 0.15% [Alphanova, Orchidia, Egypt] twice daily for one week were recommended. All operations were conducted using an ophthalmic Nd: YAG laser [Ultra Q, YAG laser, Ellex, USA] and an Abraham capsulotomy lens. The impact of a Nd: YAG laser posterior capsulotomy on the patient's refractive state was evaluated.

Statistical analysis

Statistical analysis was performed using SPSS program for Windows 7, version 23, with continuous variables presented as mean values -/+ standard deviation [SD], and categorical variables presented as percentages. Changes in patient refractions in terms of spherical and cylindrical powers were compared separately. Analyses of cylindrical power excluding the axis were performed. The data set as P-value < 0.05 will be considered statistically significant.

RESULTS

The study population consisted of 33 individuals with a mean age of 63.45 + 7.69 years. The majority of participants were female (63.6%) and had posterior capsular opacity on the right side (60.6%). The mean time between cataract surgery and YAG capsulotomy was 13.30±3.71 months (range, 7 months to 20 years). The average amount of energy delivered to each eye was 3.02±0.99 mJ (range, 1.7 to 5 mJ). The shot count was 27.82±9.043 (range 12 to 44).
The grading of the opacity varied, with 54.5% classified as moderate and 36.4% classified as severe. These baseline characteristics were of posterior capsular opacity patients summarized in Table 1.

Table 1. Baseline characteristics of the study population

Variables	No.	%
Age /year		
≤50	1	3
51 – 60	12	36.4
61 – 70	13	39.4
>70	7	21.2
Sex		
Male	12	36.4
Female	21	63.6
Side of posterior capsular opacity		
Right	20	60.6
Left	13	39.4
Grading of posterior capsular opacity		
Mild	3	9.1
Moderate	18	54.5
Sever	12	36.4

The results of the study indicated a significant difference in mean values after capsulotomy compared to before the procedure, with a p-value of 0.001.
The results of the study suggest that capsulotomy had a significant impact on the participants' visual acuity with a difference of about -0.28+0.14, with a notable change in sphere by -0.35+0.49, cylinder -0.40+0.47 and spherical equivalent measurements by -0.55+0.63 after the procedure.
One month follow-up showed significant improvement in visual acuity over one month by 0.29+0.13. The changes in sphere 0.37+0.52, cylinder 0.47+0.52, and SE values 0.63+0.69, indicate a trend towards better refractive outcomes. The stability of the cylinder axis suggests a consistent correction of astigmatism post-operatively. Overall, the results demonstrate positive long-term outcomes in this study (Table 2).
Double-angle plots compared the average centroid preoperatively to one month (Figure 1) When compared to the one-month mark, the preoperative centroid was 0.52D at 26°±1.31D and postoperative was 0.65D at 27°±1.23D (Figure 1). For these 33 eyes with follow-up visits, the percent distribution of eyes within cylinder ranges was plotted for pre- and postoperative visits (Figure 2).

Table 2. Refractive Changes at One Week and One Month After Nd: YAG Capsulotomy

Follow-Up Intervals	Before Capsulotomy	after Capsulotomy	Difference	P value
One-week follow-up.				
Sphere, (D)	0.24 (2.77)	0.59 (2.69)	-0.35 (0.49)	**0.001*a**
Cylinder, (D)	-1.62 (0.90)	-1.22 (0.85)	-0.40 (0.47)	**0.001*t**
SE, (D)	-0.58 (2.90)	-0.03 (2.85)	-0.55 (0.63)	**<0.001*a**
Cylinder Axis,	105.15 (41.32)	103.64 (44.22)	1.52 (8.70) ‡	**0.325t**
CDVA, logMAR	0.38 (0.13)	0.66 (0.14)	-0.28 (0.14)	**<0.001*a**
One-month follow-up				
Sphere, (D)	0.24 (2.77)	0.63 (2.71)	0.37 (0.52) ‡	**0.001*a**
Cylinder, (D)	-1.62 (0.90)	-1.15 (0.84)	0.47 (0.52) ‡	**<0.001*t**
SE, (D)	-0.58 (2.90)	0.053 (2.87)	0.63 (0.69) ‡	**<0.001*a**
Cylinder Axis,	105.15 (41.32)	103.64 (44.22)	-1.52 (8.70)	**0.325t**
CDVA, logMAR	0.38 (0.13)	0.67 (0.13)	0.29 (0.13) ‡	**<0.001*a**

Statistically significant with a p-value <0.05. ‡Positive differences refer to counterclockwise change, negative differences refer to clockwise change. Compare preoperative and postoperative measurements using the Wilcoxon Signed Ranks Test. t Comparing preoperative and postoperative measurements using paired t-test. **Abbreviations: BDVA, best corrected visual acuity; D, diopter; logMAR, logarithm of the minimum angle of resolution; SD, standard deviation; SE, spherical equivalent.*

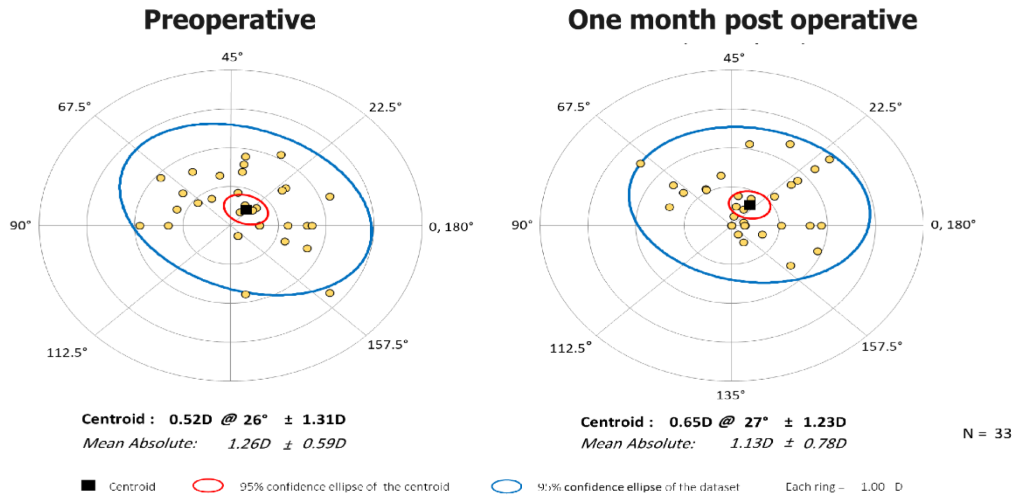

Figure 1. Pre- and Postoperative Double-Angle Plots. (Preoperative) The centroid was 0.52D@26°±1.31D (black block). The mean absolute value was 1.26D±0.59D.
(Postoperative) The centroid was 0.65D@27°±1.23D (black block). The mean absolute value was 1.13D±0.78D.

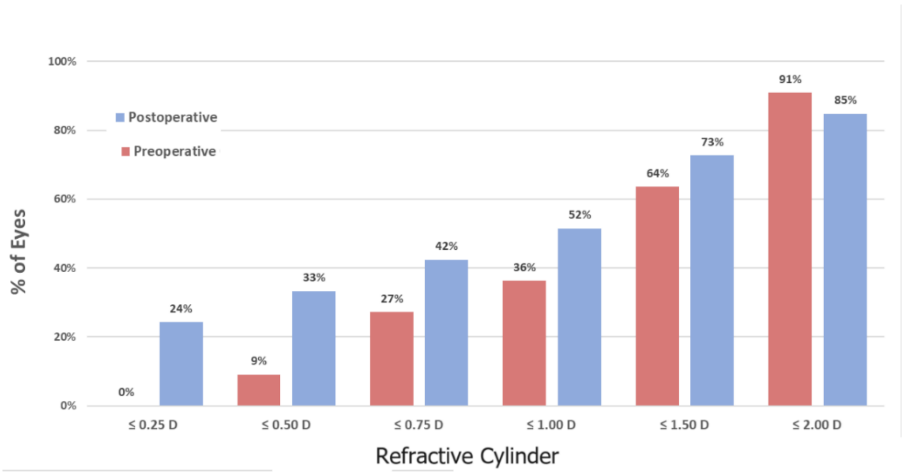

Figure 2. Distribution of Eyes Within Cylinder Ranges Pre- and Postoperatively.

DISCUSSION

Cataract surgery is a common procedure performed by ophthalmic surgeons. Even with advances in IOL design and surgical techniques, PCO is still a prevalent cause of reduced visual acuity [12,13]. The best treatment for PCO-related loss of visual acuity is nd: YAG laser therapy.
Research has shown that various techniques for Nd: YAG laser capsulotomy modify the anterior segment's morphology. The SE values of the subjects decreased concerning refraction. Beginning with the first session, the hyperopic shift persisted for the duration of the second and third appointments. After YAG laser capsulotomy, some studies found no discernible change in SE values [14,15], whereas others found a hyperopic shift [16]. A 0.16-0.36 D hyperopic shift was revealed by Karahan et al. [16] based on the YAG laser capsulotomy's breadth. A hyperopic shift may emerge from posterior IOL migration brought on by YAG capsulotomy.
Regarding the PCIOL's position. While some research has found a slight posterior shift [9], others have not seen the effect [12]. It is frequently undetectable and generally subtle. In theory, the IOL's retrograde motion could result in a hyperopic shift. A posterior migration and consequent hyperopic shift are seen in patients with PMMA intraocular lenses [11]. The capsulotomy size and intraocular lens type determine how much of a shift there occurs. Additionally, it has been discovered that greater posterior mobility is linked to larger capsulotomies [11]. Following Nd: YAG laser capsulotomy, Chua et al. discovered that the change in spherical equivalent was statistically negligible [13]. With a large capsulotomy size, Eyyup et al. showed a greater hyperopic shift and elevated IOP [10]. In pseudophakic eyes, the treatment may also have an impact on pseudo-accommodation [14]. There have been instances of IOL dislocation following Nd YAG capsulotomy resulting in notable alterations to the eye's refractive condition [15–17].
Our investigation revealed a statistically significant hyperopic shift one week and one month following the procedure; however, throughout the follow-up, the hyperopic shift stabilized from the first week till the end of the first month.
One such effect is on the myofibroblasts in PCO, which will cause an IOL position shift [13]. IOP alterations, IOL damage and dislocation, iridocyclitis, vitreous hemorrhage and vitreous, retinal detachment, and macular edema are among the several problems associated with this surgery, despite its reliability. Nd: The YAG laser capsulotomy could alter the refraction. Regarding the modifications to the refractive status, opinions differ. Large capsulotomy sizes have been linked to posterior IOL movement and hyperopic shift, according to certain authors.
Research on the PCIOL position after Nd: YAG capsulotomy has indicated a propensity for a lens position change [15]. The process may have an impact on where the PCIOL is located. A slight posterior shift has been noted in some research [15], while the effect has not been seen in others [12]. It may go unnoticed and is frequently subtle. The IOL's retrograde migration could theoretically be the reason for the hyperopic shift. Patients with PMMA intraocular lenses are more likely to experience a posterior movement and consequent hyperopic shift [16]. The size of the capsulotomy and the type of intraocular lens determine how much of a shift occurs. Increased posterior mobility has also been observed to be correlated with larger capsulotomies [16].
The present study found a significant difference in mean values after capsulotomy compared to before the procedure, with a significant impact on visual acuity. A one-month follow-up showed significant improvement in visual acuity, suggesting better refractive outcomes. The stability of the cylinder axis suggests a consistent correction of astigmatism post-operatively. Overall, the results demonstrate positive long-term outcomes. Waseem and Khan stated that laser capsulotomy enhanced vision and reduced lenticular astigmatism. Changes in AC depth may affect optical errors, intraocular lens placement, and intraocular pressure [18].
There was no significant difference in corneal topography k1 readings between pre-session and post-session, with the highest value in pre-session [44.29±1.54] and lowest in post-session [43.79±1.37], with a mean difference of -0.50. However, there was a significant difference in pre-session and average k readings [44.68±1.24][19]. Patients' spherical equivalent values dropped post-YAG capsulotomy, but hyperopia increased post-capsulotomy, possibly due to the procedure's width, according to Karahan et al [10,20].
Our study results imply that energy consumption, shot count, and visual acuity may be related in some way, but more investigation is required to completely comprehend these relationships.
The study's limitations include small sample size and data from a single hospital, suggesting additional centers for data aggregation and longer period follow-up for potentially varying long-term outcomes.

CONCLUSION

Patients who underwent Nd: YAG posterior capsulotomy experienced improved vision, with most refraction changes leading to a shift towards hyperopia. The aperture created could significantly influence the cylindrical adjustment. A larger sample size and a randomized control trial would be needed to determine the refractive shift pattern.

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Conflicts of Interest
The authors declare no conflicts of interest.

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التغيرات الانكسارية بعد بضع المحفظة بالليزر Nd.YAG في المرضى الكاذبين

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المستخلص
غالبًا ما تؤدي جراحة إزالة المياه البيضاء بعد العملية الجراحية إلى عتامة المحفظة الخلفية، مما يتسبب في انخفاض حدة البصر وازدواجية الرؤية في عين واحدة. تشمل العوامل عمر المريض، ونوع العدسة وتقنية الجراحة. يمكن أن يسبب شق المحفظة YAG، وهو إجراء غير جراحي، مضاعفات مثل ارتفاع الضغط وتلف عدسة العين الداخلية والالتهاب وانفصال الشبكية. تهدف الدراسة إلى تقييم تأثير شق المحفظة الخلفي بالليزر Nd: YAG على الحالة الانكسارية لعيون المرضى. أجريت هذه الدراسة في مستشفى بنغازي التعليمي للعيون في ليبيا. تكونت العينة من المرضى الذين أصيبوا بالمحفظة الأمامية أثناء جراحة اعتام عدسة العين وأصيبوا بشق المحفظة الأمامية. تم اختيار المرضى بناءً على حالتهم وخضعوا لفحص شامل للعين، بما في ذلك الانكسار، وحدة البصر دون مساعدة، وحدة البصر المصحح. بعد العملية الجراحية، تم إجراء عمليات شق المحفظة الخلفية باستخدام ليزر Nd: YAG. تضمنت التقنيات الجراحية إعطاء ضربة واحدة من ليزر Nd: YAG، باستخدام التخدير الموضعي، وتنظيف الكبسولة الخلفية المركزية، وتطبيق مستويات الطاقة. متوسط العمر 63.45 + 7.69 سنة، غالبيتهم من الإناث (63.6%) و (60.6%) في العين اليمنى. أثر الإجراء بشكل كبير على حدة البصر لدى المشاركين (P <0.001)، مع تغييرات في القياسات الكروية والأسطوانة و المعادلة الكروية (0.001>P). أظهرت المتابعة لمدة شهر تحسنًا ملحوظًا في حدة البصر، مع اتجاه نحو نتائج انكسارية أفضل. يشير استقرار محور الأسطوانة إلى تصحيح ثابت للاستجماتيزم بعد العملية الجراحية. وتظهر نتائج إيجابية على المدى الطويل في هذه الدراسة. مع متوسط النفطة الوسطى هو D0.52 عند 26 درجة ± D1.31 و D0.65 عند 27 درجة ± D1.23 في شهر واحد. وجدت الدراسة أن الأفراد الذين خضعوا لعملية شق المحفظة الخلفية Nd: YAG كانت لديهم رؤية أفضل، مع تغيرات الانكسار التي تؤدي في كثير من الأحيان إلى تحول طول النضر.
الكلمات الدالة. Nd: ليزر YAG، جراحة الساد، الكرة، الأسطوانة، المكافئ الكروي.