Int Ophthalmol (2019) 39:1199–1204
https://doi.org/10.1007/s10792-018-0908-0

REVIEW

Outcomes of presbyopia-correcting intraocular lenses after laser in situ keratomileusis

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Received: 5 October 2017 / Accepted: 22 March 2018 / Published online: 28 March 2018

Abstract

Background Laser in situ keratomileusis (LASIK) is the most common refractive surgery in young patients, which aims at providing a clear distance vision without the use of spectacles. With time, these patients develop symptomatic cataract, which affects activities of daily living, and to improve visual acuity, intraocular lens (IOL) implantation can be considered. In post-myopic LASIK patients, to allow continuation of spectacle independence, the implantation of presbyopia-correcting IOLs is a suitable option. The purpose of this retrospective case series is to report the visual outcome and quality in post-myopic LASIK eyes after the implantation of AT LISA tri839MP IOL.

Method Twenty eyes of 13 patients with history of myopic LASIK within 20 years underwent phacoemulsification by one single surgeon. All eyes were implanted with AT LISA tri839PMP IOL, and their outcomes were evaluated at 6 months postoperation.

Results The mean postoperative uncorrected distance visual acuity (VA) is 0.28 ± 0.29, while the corrected distance VA is 0.06 ± 0.14. The mean postoperative uncorrected near VA is 0.02 ± 0.05, while the corrected near VA is 0.01 ± 0.02. The mean postoperative manifest refraction spherical equivalent (SE) is -0.92 ± 0.76D. There is a statistically significant difference between the preoperative and postoperative refraction ($p = 0.02$), which shows a postoperative myopic shift. There is also a statistically significant difference between the mean targeted SE and postoperative manifest refraction SE ($p = 0.00$). Only one out of 20 eyes (5%) reported halo and glare symptoms. Ten out of 20 eyes (50%) are able to achieve spectacles independence.

Conclusion In conclusion, in post-myopic LASIK eyes, AT LISA tri839MP provides a good visual outcome at both near and distance, but is more predictable at near than at distance. There is a myopic shift in the postoperative SE. Visual quality is satisfactory and has not been exacerbated. Most patients can remain to be spectacles free at all distances.

Keywords Trifocal intraocular lens · Laser in situ keratomileusis · Spectacle independence

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Introduction

Laser in situ keratomileusis (LASIK) is one of the most common refractive surgeries done worldwide [1]. The main aim of the surgery is for spectacle independence. However, with time, patients develop symptomatic cataract, which affects activities of daily living, and to improve visual acuity, the implantation of intraocular lens (IOL) can be considered. To allow continuation of spectacle independence, there are various treatment methods including the use of monovision, laser blended vision, and the use of presbyopia-correcting IOLs.

There are many different types of presbyopia-correcting IOLs. Bifocal IOLs are initially helpful in reducing dependence on glasses; however, they are not able to provide a full range of vision. Patients with bifocal IOLs implanted usually have a drop in visual acuity at intermediate distance [2, 3], which is essential for common daily activities such as computer and mobile phone usage. Trifocal IOLs aim at providing a wider range of spectacle independence as compared to bifocal IOLs. The idea is based on a diffractive technology such that light is distributed to three different foci, providing three useful focal distances—near, intermediate, and far [4, 5]. Reports have shown that trifocal IOLs have comparable visual outcomes as those of bifocal IOLs and are able to provide a better visual acuity at intermediate distance [2, 3].

AT LISA tri839MP (Carl Zeiss Meditec, Jena, Germany) is one of the first trifocal IOLs developed using a 100% diffractive technology. The IOL is an aspheric IOL, which aims at correcting the spherical aberration of the cornea. The IOL has an optimized optic design with an additional dedicated focal point for intermediate vision without compromising distance and near vision. The near and intermediate additions are + 3.33D and + 1.66D, aiming at providing a comfortable reading and intermediate distance of approximately 40 and 80 cm, respectively.

In eyes with previous myopic LASIK, studies have shown that after the implantation of multifocal IOLs, patients are able to achieve a good near and distance visual acuity [6, 7]. Aspheric IOLs have been shown to have a better visual outcome in terms of optical quality than spherical IOLs; this is probably due to an increase in spherical aberration on the cornea after LASIK [8], which is being counteracted by the negative spherical aberration of aspheric IOLs.

To our knowledge, there are currently limited studies reporting the visual outcomes of trifocal IOLs after myopic LASIK. The purpose of this retrospective case series is to report the mean best uncorrected and corrected monocular VA at near and distance, the mean refractive outcome, the visual symptoms including halo and glare as well as the rate of spectacle independence in post-myopic LASIK eyes after the implantation of AT LISA tri839MP IOL.

Materials and methods

Patients

This retrospective case series was conducted from July 2014 to January 2017. The inclusion criteria were aged between 40 to 70 years old, a history of myopic LASIK done within 20 years, and a follow-up period of 6 months or more after cataract surgery and IOL implantation. The exclusion criteria were eyes with preexisting ocular conditions that might affect the postoperative visual acuity. All patients were diagnosed with symptomatic cataract affecting activities of daily living and were all considered to be suitable candidates for trifocal IOL implantation to improve vision. The ethics committee of the Hong Kong Sanatorium Hospital has approved the study.

Surgical technique

All patients underwent phacoemulsification by one single surgeon at the ophthalmology operating theater of Hong Kong Sanatorium Hospital. A 2.75-mm corneal incision was created either superiorly or temporally with a keratome. Ophthalmic viscosurgical device was injected into the anterior chamber, and continuous curvilinear capsulorhexis was created. Hydrodissection and hydrodelineation were performed, and the nucleus was split. Phacoemulsification using the Infiniti Vision System (Alcon Laboratories Inc.) was done. Irrigation and aspiration of the residual cortex was completed. In all of the cases, AT LISA tri839MP IOL was implanted into the capsular bags. There were no complications noted in all cases.

Preoperative and postoperative examinations

All patients underwent a preoperative ophthalmologic examination that included measurements of corrected distance visual acuity (CDVA), manifest refraction spherical equivalent, slit-lamp biomicroscopy, and dilated fundus examination. Axial length and anterior chamber depth measurements were performed with the IOL Master 500 (Carl Zeiss Meditec AG, Jena, Germany). The Holladay 2 formula was used for IOL power calculations. The surgeon selected the IOL power at his own discretion, aiming at − 0.50D to − 1.00D.

The postoperative measurements included uncorrected and best corrected near visual acuity by the Jaeger eye chart and distance visual acuity by Snellen eye chart at 20 feet in the form of the logMAR visual acuity score, the postoperative manifest refraction spherical equivalent. Patients were also asked about visual symptoms including postoperative halo and glare. Patients were also asked about feasibility of spectacle independence in all distances. All patients were followed up for 6 months or more, and outcome measures were taken at 6 months after cataract surgery.

Statistical analysis

All statistical analysis was performed using SPSS (SPSS Inc., Chicago, II.). Statistical analysis included descriptive data for demographics, visual and refractive outcomes, visual quality, and spectacle independence. The Wilcoxon signed-ranks test was used to compare preoperative and postoperative outcomes. Differences were considered statistically significant when p value < 0.05.

Results

The study evaluated 20 eyes of 13 patients. Seven patients had IOL implantation done in both eyes, while six patients had IOL implantation done in one eye only while the fellow eye remained phakic throughout the study period. The female to male ratio is 11:2. The mean age is 53 ± 6.09 years. The mean uncorrected distance visual acuity (UDVA) is 0.14 ± 0.24, while the mean manifest refraction spherical equivalent is − 2.13 ± 2.20D. The mean axial length is 26.5 ± 1.58 mm. The mean targeted refraction is − 0.32 ± 0.15D.

Visual acuity

At 6 months, the mean postoperative UDVA is 0.28 ± 0.29, while the corrected distance visual acuity (CDVA) is 0.06 ± 0.14. The mean postoperative uncorrected near visual acuity (UNVA) is 0.02 ± 0.05, while the corrected near visual acuity (CNVA) is 0.01 ± 0.02.

Refraction

The mean postoperative manifest refraction spherical equivalent is − 0.92 ± 0.76D. There is a statistically significant difference between the preoperative and postoperative refraction ($p = 0.02$). There is also a statistically significant difference between the mean targeted spherical equivalent and postoperative manifest refraction spherical equivalent at 6 months ($p < 0.001$). Eleven out of 20 eyes (55%) achieved a post-op spherical equivalent within 0.5D from the targeted spherical equivalent.

Figure 1 shows the linear correlation between the targeted SE and the postoperative SE. The coefficient of determination (R^2) is 0.91.

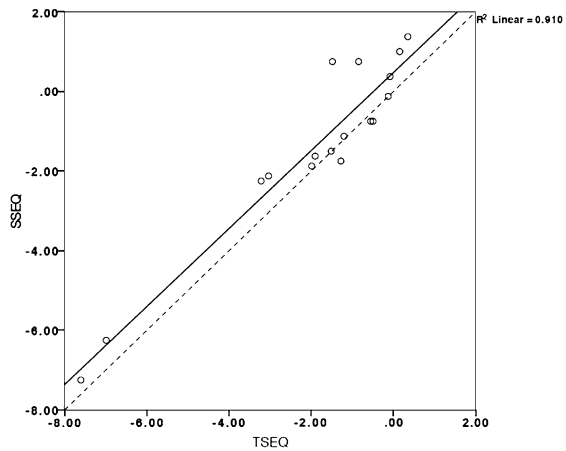

Fig. 1 Linear correlation between the targeted SE and the postoperative SE. The coefficient of determination (R^2) is 0.91

Visual quality

Patients were asked specifically about symptoms of halo and glare during the postoperative follow-up consultations. Only one eye out of 20 eyes (5%) reported halo and glare symptoms after IOL implantation.

Spectacle independence

Ten out of 20 eyes (50%) were able to be glasses free for daily living.

Discussion

The main purpose for patients to undergo myopic LASIK surgery is to avoid the need for glasses. However, as patients age, they develop symptomatic cataract, which may affect activities of daily living, and these patients will consider cataract surgery to improve vision. To allow continuation of spectacle independence for near, intermediate, and distance vision, besides monovision and laser blended vision, implantation of a trifocal IOL is another suitable option. This study aims to evaluate the visual outcome, visual quality, and rate of spectacle independence of AT LISA tri839MP trifocal IOL in patients with myopic LASIK done. To date, there are few studies evaluating the visual outcome and visual quality of presbyopia-correcting IOLs in eyes of patients who underwent previous myopic LASIK surgery; this is the first study evaluating trifocal IOLs.

For distance vision, our results show that there is no statistically significant difference between the preoperative and postoperative CDVA ($p = 0.09$). However, this is probably due to a preexisting good preoperative CDVA in post-myopic LASIK eyes. Similar studies have also shown a good postoperative distance VA after the implantation of multifocal IOL in post-myopic LASIK eyes. Chang et al. [9] reported a good CDVA in post-myopic LASIK eyes after the implantation of the Tecnis ZMA00 and ZMB00 MIOLs, which are both diffractive bifocal IOLs [9]. The postoperative CDVA did not differ from the unoperated eye. Fernandez-Vega et al. [7] also reported an improvement in CDVA in post-myopic LASIK eyes after the implantation of AcriLISA 366D IOL, which is an aspheric bifocal IOL. The study concluded that in post-myopic LASIK eyes, aspheric IOL had visual quality similar to that in phakic age-matched eyes. Similarly, Alfonso et al. [6] also reported a good postoperative distance VA after the implantation of AcriLISA 366D IOL in post-myopic LASIK eyes, which was comparable to that in phakic eyes. We also compared our data with eyes without previous myopic LASIK or any refractive surgery done, i.e., virgin eyes. In our study period, 47 virgin eyes of 32 patients were implanted with AT LISA tri839MP. The mean preoperative CDVA is 0.04, while the mean postoperative CDVA is 0.00; their difference is significantly different ($p = 0.04$). There is also no statistically significant difference between the postoperative CDVA of post-myopic LASIK eyes and virgin eyes. This shows that after the implantation of AT LISA tri839MP, the postoperative distance vision in myopic LASIK eyes is comparable to that of virgin eyes.

As for near vision, after the implantation of AT LISA tri839MP, the mean UNVA in post-myopic LASIK eyes is 0.02 while the CNVA is 0.01. The difference between the corrected and uncorrected VA at near is less as compared to that of distance. This shows that in post-myopic LASIK eyes, the visual outcome of trifocal IOL is more predictable at near than at distance. Chang et al. [9] reported a significantly better UNVA in the operated eye than that of the unoperated eye. We also compared the near vision with virgin eyes. There is no statistically significant difference between the postoperative CNVA of post-myopic LASIK eyes and virgin eyes. This also shows a comparable postoperative near vision.

As for refraction, the difference between the mean postoperative SE and the mean targeted SE is -0.6, and there is a statistically significant difference between the SEs ($p = 0.00$). This shows that after the implantation of AT LISA tri839MP trifocal IOL in post-myopic LASIK eyes, there is a myopic shift. In virgin eyes, the difference between the mean postoperative SE and mean targeted SE is $+0.2$ and there is also a statistically significant difference ($p = 0.00$). This result provides an important reference for surgeons at targeting refraction in future implantation of trifocal IOLs in post-myopic LASIK eyes, which differs from that of virgin eyes.

Visual quality has always been an important aspect in the evaluation of trifocal IOLs. Visual symptoms such as halo, glare, blurring of images, or difficulties

with night vision have been reported. Although some studies report that these symptoms are usually not disturbing and become less noticeable over time [10, 11], visual symptoms such as halo and glare are still reported to be significant in approximately 5.5% of patients in all types of multifocal IOLs [5].

In our study, only one patient reported significant halo and glare. In similar studies, visual quality such as halos, night glare, and starbursts has also been evaluated. Chang et al. [9] evaluated visual quality by the means of a questionnaire. In the study, 33% of patients reported a severity score of 3 or more. The difference in the score was not statistically significant. On the contrary, 83% of patients reported a satisfaction score of 3 or more. In virgin eyes, 11 out of 47 eyes (23.4%) reported such postoperative visual symptoms. There is no statistically significant difference between the visual qualities of post-myopic LASIK eyes and virgin eyes ($p = 0.91$). Hence, although after successful myopic LASIK procedures, patients have been reported to display an increase in halo and glare, especially in night vision conditions [12], and the symptoms are shown to have not been exacerbated after the implantation of trifocal or bifocal IOLs.

To address the main aim of the implantation of trifocal IOLs, spectacle independence has also been evaluated in our study. Postoperatively, 50% of post-myopic LASIK eyes were able to be spectacle independent for daily living. In Chang's [9] study, after the implantation of a bifocal IOL in post-myopic eyes, 78% did not need spectacles at all distances. As for virgin eyes, 32 out of 47 eyes (68%) reported success in spectacle independence. There is no statistically significant difference between post-myopic LASIK eyes and virgin eyes ($p = 0.16$). This shows that the continuation of a glasses-free living is possible after the implantation of both bifocal IOL and trifocal IOL in post-myopic LASIK patients.

In conclusion, in eyes that had post-myopic LASIK, AT LISA tri839MP provides a good visual outcome at both near and distance; however, visual outcome is more predictable at near than at distance. After successful implantation, there is a myopic shift in the postoperative spherical equivalent. This result allows surgeons to adjust their targeted refraction when considering the implantation of trifocal IOLs in post-myopic LASIK patients. Postoperatively, visual quality including halo and glare is satisfactory and has not been exacerbated. Also, most patients can remain to be spectacles free at all distances. However, further studies of a larger sample size of presbyopia-correcting IOLs in post-myopic LASIK eyes should also include the objective evaluation of visual quality under both photopic and mesopic conditions by standardized questionnaires, objective evaluation of contrast sensitivity, and the visual outcome on binocular viewing.

Compliance with ethical standards

Conflict of interest All authors have no conflict of interest to declare.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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

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