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Research Article

Comparative Study Between the High Order Aberrations Before and After Cataract Surgery Using Two Different Types of IOLS

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Abstract

Purpose: To compare between Total High Order aberrations, Comma, Spherical Aberrations and Terefoil before and after femtosecond assisted Cataract Surgery using Tecnis (AMO) and Akreous (Baush and lomb) intraocular lenses.

Methods: A prospective, randomized comparative interventional study was done by the same single surgeon on 30 eyes of 15 patients had Femtosecond assisted Cataract Surgery (FLACS) using the Victus (Baush and Lomb) Platform. High order aberrations were measured using the I-tracy machine before and after surgery by one month.Tecnis-1 (Abott) IOL was inserted in one eye and Akreous (Baush& Lomb) was inserted in the contralateral eye of each patient.

Results: All patient showed a significant improvement of log MAR best spectacle corrected visual acuity ,total higher order aberrations ,coma trefoil and spherical aberration after surgery with no statistical significant differences between both groups .

Conclusions: There is no Statistical significance difference between The Tecnis IOL of Abott and Akreous of Baush and Lomb as regards the improvement in The total high order aberrations, spherical aberrations, Coma and Terefoil.

Keywords: *IOL; Cataract; Aberrations; Femtosecond Laser; Surgery; Aspheric*

Introduction

Cataract surgery is the most commonly performed intra ocular surgery with increased number of candidates seeking both cataract removal and spectacle independence [1]. Femtosecond laser is a promising new technology for the field of cataract surgery promoting more precision during crucial surgical stages: lens fragmentation, anterior capsulotomy and corneal incisions [2]. It presents an opportunity for improvement of both safety and efficacy, resulting in a more predictable and precise anterior capsulotomy that in term affects IOL positioning and centeration [3].

Several changes have occurred during the journey of IOL manufacturing since the Sir Ridley implanted the first successful IOL on November 29th 1949, at St. Thomas' hospital in London [4] till the appearance of several premium IOLs in the market [5].

The human cornea is not spherical but has an aspheric surface producing a positive spherical aberration that is it is partially neutralized by the young human crystalline lens that have a negative spherical aberration [6]. With aging the human lens gains positive spherical aberration that together with the positive spherical aberration of the cornea produces image degradation [7]. During cataract extraction and IOL implantation the implanted conventional biconvex spherical IOL also add to the positive spherical aberration of the cornea. Two strategies can be applied to overcome this problem; either using an IOL with minimum spherical aberrations so that no additional spherical aberration is added to the corneal spherical aberrations or IOL with negative spherical aberrations to balance the normally positive corneal spherical aberrations [8]. Aspheric IOLs attempt to improve pseudophakic vision by controlling spherical aberrations. In his study we are using 2 types of aspheric IOL Tecnis 1 (Advanced Medical Optics (AMO)/ Abott), is characterized by aspheric anterior surface while Akreos (AO, Bausch & Lomb) has aspheric anterior and posterior surfaces [9] Akreos IOLs have four-haptic design that helps to maximize stability and centration in the capsular bag. It maintains direct contact with the posterior capsule, forming a mechanical barrier against lens epithelial cell (LEC) migration. The optics and haptics of the lens have square edges and a 360° continuous posterior barrier edge, further inhibiting LEC migration [10]. The Tecnis 1 IOL is a single piece aspheric hydropobic acrylic IOL that also has a s 360 degree square edge to minimize PCO formation [11].

By integrating wavefront aberrometry with corneal topography, the iTrace (Tracey technologies, USA)provides a unique analysis that subtracts corneal from total aberrations in order to isolate the internal aberrations of the eye [12]. The iTrace measures quality of vision and visual function using a fundamental thin beam principle of optical ray tracing. The iTrace sequentially projects 256 near-infrared laser beams into the eye to measure forward aberrations, processing data point-by-point. This 5-in-1 system provides auto-refraction, corneal topography, ray tracing aberrometry, pupillometry and auto-keratometry [13].

Patients and Methods

This is a prospective, randomized comparative interventional study carried out on 30 eyes of 15 patients suffering from bilateral significant cataract who were scheduled for femtosecond laser assisted cataract surgery by the same surgeon (A.M). All cases were operated using Victus Platform (Bausch + Lomb Technolas.) at Alex Eye Center, Alexandria. Ethics committee at the faculty of medicine, Alexandria university approved this study and a written informed consent was obtained from each patient according to Declaration of Helsinki. High order aberrations were measured using the I-tracy ray tracing aberrometer before the surgery and 1 month after it by the same operator. Wavefront measurements were performed in a dark room and were standardized to a 4.5-mm pupil. No dilating drop was used to assess the aberration profile of the natural view normally experienced by the patient. We chose to perform aberrometry measurements without applying mydriatic drops as we believe that results of a natural aberrometry profile are more representative for optical performances of the eye than results of a 6- or 7-mm pharmacologically dilated pupil.Tecnis-1 (AMO, Abott) IOL was inserted in one eye and Akreous (Baush and Lomb) was inserted in the contralateral eye of each patient.

Inclusion Criteria

Patients with visually significant cataract affecting quality of life. Patients with history of glaucoma, macular diseases, ocular inflammation, ocular surface abnormality or corneal scars that may affect aberrometer measurement were excluded from this study Patients with visually significant cataract affecting quality of life. Patients with history of glaucoma, macular diseases, ocular inflammation, ocular surface abnormality or corneal scars that may affect aberrometer measurement were excluded from this study.

Surgical technique

All study subjects had femtosecond laser assisted cataract surgery using Victus platform (The capsulotomy is centered within the pupillary border. The diameter of the capsulotomy is typically defined in settings priorto the procedure (approximately 5.0 mm in most cases). Victus platform uses diode-pumped solid laser having a Pulse duration 500fs and a Wavelength of 1028 nm Pulse frequency is 160 kHz can rise up to 320 kHZ.

The surgeon chooses a lens fragmentation pattern based on the density of the nucleus and surgeon preference. Choosing the number of segments as well as the degree of lens softening depending on the lens grade. Commonly used patterns include 4, 6, or 8 segments with or without the use of lens softening a surgeon-defined safety zone from the posterior capsule (500 mm) is automatically applied by the imaging platform and visualized on the OCT guidance for approval by the surgeon before the laser is applied. The systems allow surgical adjustment of this zone based on the evaluation of the OCT or 3-D CSI images. Finally, the arcuate incisions, paracentesis, and clear corneal wound are created. Relaxing incisions are made on the surface. The arcuate incisions are generally set at a default depth of 80% at the peripheral limbus.

Once the laser treatment has been completed, the suction is released, the patient interface is removed, and the patient is slowly undocked from the laser. The surgeon proceeded with phacoemulsification immediately using infinite phacoemilsification machine (INFINITI® Vision System, Alcon laboratories, USA). After cortical clean up, viscocohesive ocular viscoelastic (HEALON® OVD, Abott, USA) is used to fill the lens capsule and anterior chamber followed by insertion of the chosen type of IOL then careful complete removal of OVD is done in all cases. After this wound stromal hydration is done. Followed by installation of topical antibiotic and steroid eye drops and removal of speculum and drappings then the operated eye is patched with sterile patch.

Postoperative treatment and follow up

The topical antibiotic moxifloxacin (Vigamox, Alcon Laboratories, USA) and steroids (prednisolone; PredForte, Allergan, Ireland) were used at the termination of surgery then postoperatively every hour during the first day, and then every 4 hours for 2 weeks with gradual tapering of steroids. All patients were examined at day 1 for IOL position, anterior chamber depth and the presence of any leaking wounds. Complete ophthalmological test, including UCVA, BCVA and manifest refraction were carried out after 1 week. All these outcome criteria were examined again after 1 month together with wave front analysis. All complications, if any, were documented. Cases with less than 1 month follow up were excluded from the study.

Aberrometry Measurements

Total, corneal, and internal optical aberrations were measured using the Itracey.

This device measures the auto refraction, keratometry, photopic and mesopicpupil diameters, corneal topography, and wavefront aberrations simultaneously on the same axis. All wavefront aberrations were calculated and plotted with respect to the corneal vertex. The corneal topography was measured using Placido-disk technology, and the ocular wavefront was measured using the ray tracing principle.

Total, corneal, and internal wavefront aberrations were reconstructed using a 6th order Zernike polynomial. Visual quality was described by uncorrected (UDVA) and corrected distance visual acuity (CDVA), and by MTF and Strehl ratio. Images of PSF were depicted to demonstrate characteristic image degradation in the two IOL groups groups. Point spread function is represented by a figure displaying how a point is projected on the retina by the examined eye's optical system. Strehl ratio was used to compare image quality metrics in the two groups. The Strehl ratio is defined as the ratio between the PSF of an eye examined and the PSF of diffraction limited eye.

Statistical Analysis

Data were analyzed using the Predictive Analytics Software (PASW Statistics version 18 for Windows, Hong Kong). Quantitative data were described using median, minimum and maximum, as well as mean and standard deviation. Comparison between different periods was assessed using an ANOVA test with repeated measures and Bonferroni correction. Significance test results were quoted as two-tailed probabilities. Significance of the obtained results was determined at the 5% level.

Results

Patient Characteristics

The study was conducted on 30 eyes of 15 patients scheduled for bilateral FLACS and premium aspheric IOL implantation from them 10 were females and 5 were males. There was no statistically significant differences between the 2 IOL types groups regarding age or sex. Mean patient age was 70 years ranging from 55 to 83 years. All patients were evaluated for ocular wave front analysis before and 1 months after surgery.

Zernike Polynomials

No statistically significant differences were noted in any ocular, corneal, or other internal aberrations between the two groups.

Image Quality

There is no significant difference in CDVA could be detected between both groups. However both groups should a statistically significant improvement of this parameter following surgery. The mean CDVA was 0.45 and 0.5 log MAR visual acuity in Akreos and Tecnis group respectively before the surgery and improved to a mean of about 0.9 log MAR visual acuity in both groups after surgery.

MTF value was also significantly increased in the both groups after surgery, the differences were statistically significant (Pless than 0.05).

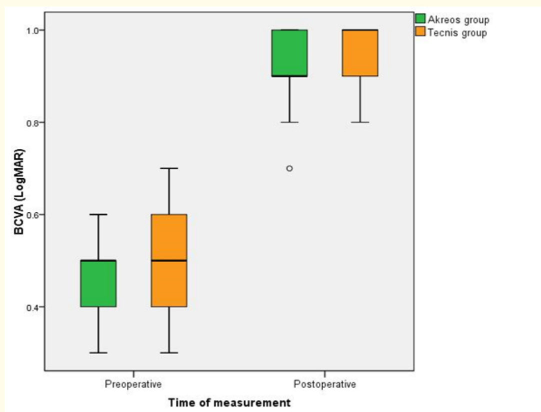

Figure 1: *Change of BCVA before and after surgery of both IOL groups.*

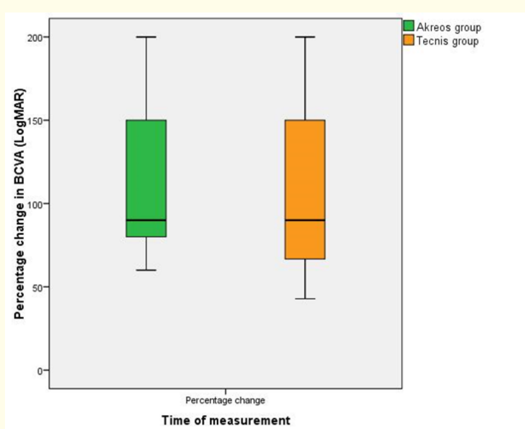

Figure 2: *Percentage of change in BCVA in both groups following surgery.*

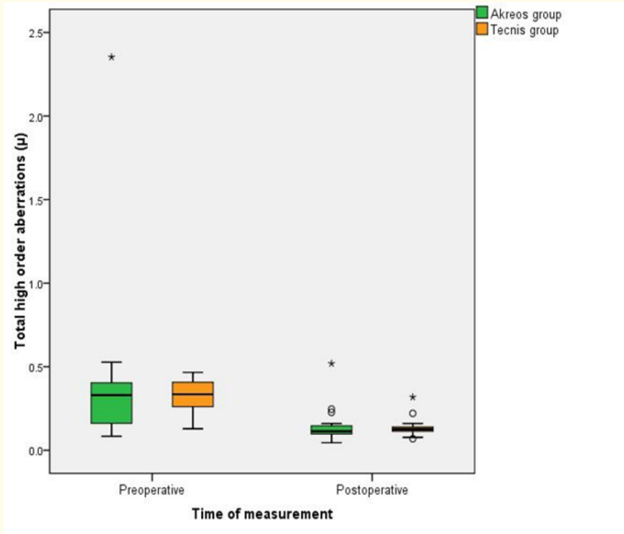

Figure 3: *Improvement of total higher order aberrations after surgery in both groups.*

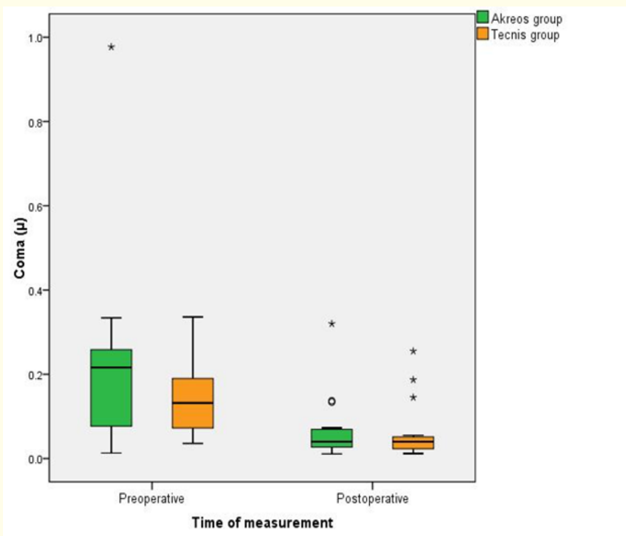

Figure 4: *Change of coma before and after surgery in both IOL groups.*

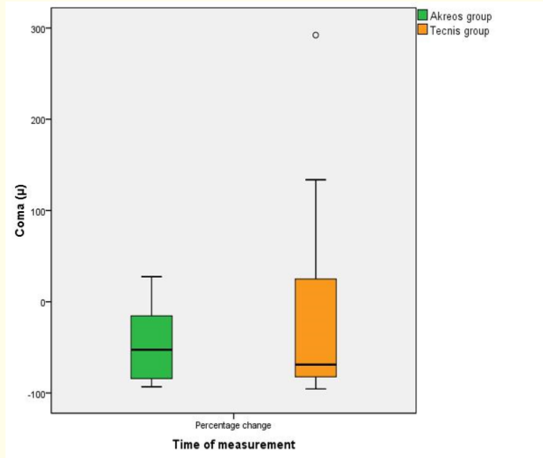

Figure 5: *Percentage of change of coma in both groups before and after surgery.*

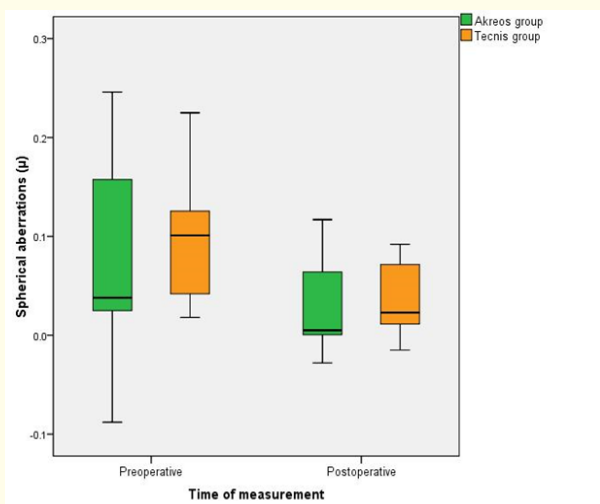

Figure 6: *Percentage of change of coma in both groups before and after surgery.*

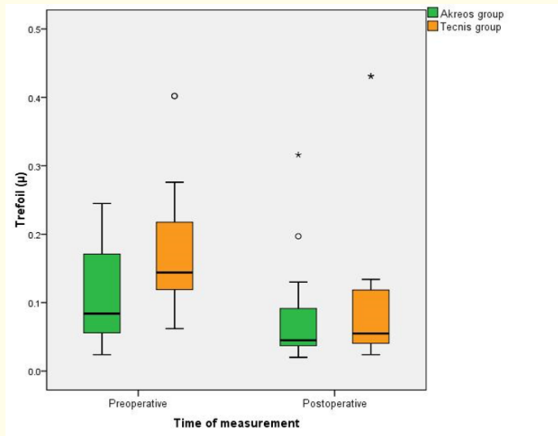

Figure 7: *Trefoil measurement before and after surgery in both gro.*

	Akreos IOL	Tecnis 1 IOL
Mean log MARCDVA	0.95	0.94
Total higher order aberrations	0.12	0.13
Coma	0.08	0.07
Spherical aberration	0.02	0.04
Trefoil	0.04	0.05

Table 1: *Visual outcomes and higher order aberration in both IOL groups at 1 month follow up.*

Intraoperative and Postoperative Complications

No intraoperative complication was reported. We have not encountered cases of post-operative infection, inflammation, nor corneal decompensation. During the follow up month, no cases developed significant PCO necessity YAG capsulotomy. No a single case of retinal detachment, giant retinal break nor a macular hole was seen.

Discussion

This study is trying to evaluate effect of implantation of different IOL designs on higher order aberration after cataract surgery assisted by femtosecond laser. Several previous studies have been conducted to assess higher order aberrations of eyes following cataract surgeries and their effect on quality of vision.

Rocha., *et al*. calculated the spherical aberration using a computed ray-tracing system for Wavefront analysis (LadarWave; Alcon Laboratories) in 2007 on 120 eyes of 60 patients, and investigated the correlation between glare disability and spherical aberration and the difference in glare disability among the different IOL types. He found that IOLs with convex-plano design, except for those with high power, had the smallest spherical aberration while IOLs which are biconvex, anterior more curved had the smallest spherical aberration at high power. IOLs with biconvex surfaces, posterior more curved) had the largest spherical aberration. The correlation between glare disability and spherical aberration was statistically significant for the first 2 types. There was no correlation between glare disability and spherical aberration for the third Type D IOLs although they showed the smallest glare disability of the 3 types [14].

A double-blind randomized controlled trial conducted by Jafarinasab., *et al*. comparing spherical aberration and contrast sensitivity among 3 different types of aspheric IOLs (Tecnis, Akreos AO, and Acrysof IQ) and one spherical IOL (Sensar). Significantly higher spherical aberration was reported with the spherical IOL and the zero-aberration aspheric IOL as compared to the negative aberration aspheric IOLs, however this advantage was pupil-size dependent. With increased pupil size from 4 to 6 mm, an increase in spherical aberration was observed for all four types of IOLs, however significantly more with the spherical IOL. Contrast sensitivity function under mesopic conditions and at low spatial frequencies (1.5 to 3 cpd) was significantly higher in the Tecnis group as compared to the others. At higher spatial frequencies (12 to 18 cpd), Acrysof IQ worked significantly better. The authors concluded that the performance of aspheric IOLs is pupil dependent and that their function deteriorates to some extent under mesopic conditions, as there was no significant difference between spherical and aspheric IOLs in mesopic contrast sensitivity at 6 cpd.

Although this study is a well-designed clinical trial with interesting results, the readers should keep in mind that the best way to compare two groups with analysis of variance (ANOVA) is using post hoc tests such as Bonferroni adjustment of type one error. This is one of the reasons for discrepancies in the results among different studies. Another explanation could be different measurement protocols [15].

Tecnis and AcrySofIQ were found to provid significantly better visual function as compared to Sensar and Akreos AO, especially with smaller pupil size. However, this difference diminished with increasing pupil size [16].

Bernard Heintz MD conducted a prospective, randomized study comparing outcomes in a bilateral comparison. The study included 34 patients who underwent routine bilateral cataract surgery and were evaluated after three months with testing of high (90 per cent) and low (10 per cent) contrast BCVA and UCVA using logMAR charts, depth of field, higher order aberrations (Zywave II, Bausch & Lomb), and a patient satisfaction questionnaire. All IOLs were perfectly centered, and the outcomes analyses showed lower total HOA and spherical aberration in eyes implanted with the TECNIS IOL. However, visual acuity and depth of field were similar for the two IOLs, and the SofPort AO was associated with slightly better patient satisfaction and fewer reports of dysphotopsias, although the differences between lenses in those two parameters were not statistically significant [17]. However, it is important to note these data are based on measurements obtained with the pupil dilated to at least 6.0mm. In daily life where pupil size is smaller, some of the higher order aberrations would be masked. And this is a significant difference from our study where the pupils were examined without dilatation.

Behndig., *et al*. reported results of a Swedish multicentre study comparing the optical performance of the Akreos Adapt AO and the aspheric silicone Tecnis Z9000. Eighty patients were randomised to implantation with one of the two IOLs in one eye and the alternate in the fellow eye. Outcomes were excellent with both IOLs. Postoperative refraction was very close to emmetropia in both groups. There were no significant differences between the eyes implanted with the Tecnis versus the Akreos Adapt AO with respect to logMAR visual acuities or contrast sensitivity at any spatial frequencies. Wavefront measurements performed using pupil sizes of 4.0, 4.5, and 5.0mm showed that total higher order aberrations were consistently significantly less in the Tecnis eyes. The difference between groups increased with increasing pupil size .However, the Akreos Adapt AO was associated with significantly better depth of field, and that benefit also increased with increasing pupil size. Patient questionnaires revealed high satisfaction with both IOLs, with a slight majority of patients (58 per cent) considering both eyes equal. However, among those patients who expressed a preference, the Akreos Adapt AO was favoured over the Tecnis by a ratio of 2:1. Less pronounced light-associated problems appeared to be the primary factor contributing to the difference. He concluded that Maximum reduction of spherical aberration did not maximize subjective visual quality. The higher perceived quality of vision with the Akreos AO IOL could be because of differences in depth of field, IOL material, or IOL design [18].

All the previous studies worked on IOLs implanted during conventional phacoemulsification procedures. Our study is, to our knowledge, the first study conducted in Egypt to compare 2 different designs of premium aspheric IOLs implanted in FLACs. However, our study has some limitations. Short follow up period is one of these limitations. Also effect of the procedure on near vision and time of spectacle independence are other potential limitations that need to be further investigated. Degree of improvement in contrast sensitivity also may be addressed in a further study. Patient satisfaction and quality of life assessment questioners may be also applied in a future large scale study with a longer period of follow up.

Conclusion

FLACS appears safe and effective procedure with many benefits in providing excellent visual and refractive outcomes for cataract surgery especially when combined with the insertion of both types of premium aspheric IOLs that show no statistical significant difference between them in reduction of higher order aberrations. However, continuous long term clinical studies of the outcomes of this surgery will provide data for cost-benefit analysis and the confirmation of its superiority over conventional surgery and /or IOLs.

Disclosure

The authors have no financial or proprietary interest in any materials or methods presented herein.

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