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The influence of corneal incision size on endothelial cell loss and surgically induced astigmatism following phacoemulsification cataract surgery

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ABSTRACT

OBJECTIVE: Corneal incision size has influence both on corneal biomechanics and intracameral fluid dynamics during phacoemulsification cataract surgery. The aim of this study was to evaluate the impact of corneal incision size on endothelial cell loss and surgically induced astigmatism (SIA) following phacoemulsification cataract surgery.

METHODS: This prospective, randomized, and comparative study included 61 eyes with senile cataracts. The patients were randomly assigned to 2.2 mm and 2.8 mm corneal incision sizes and were operated with the same phacoemulsification system. Phacoemulsifcation energy parameters, pre-operative and post-operative endothelial cell counts and corneal astigmatism values were specifically recorded. SIA was calculated according to Alpins method and the results of both groups were compared.

RESULTS: There were 31 eyes in the microincisional (2.2 mm) group and 30 eyes in the standard incision (2.8 mm) group. There was no significant difference between the groups for age and gender distribution (p=0.09 and p=0.18, respectively). Similar levels of cumulative dissipated energy was used during phacoemulsification in both groups (p=0.70). SIA was slightly higher in the standard incision group compared to microincisional group (0.47D at 64° vs. 0.37D at 61°, p=0.30). Pre-operative and post-operative uncorrected visual acuity (UCVA) was similar between the groups (p=0.45 and p=0.27).Endothelial cell loss tended to be slightly higher in the microincisional group compared to standard incision group (174.87±132.27 vs. 160.84±121.58, p=0.75), but this difference was not statistically significant.

CONCLUSION: Smaller corneal incisions slightly reduced SIA, but tended to induce more endothelial cell loss. This small difference in SIA did not cause a significant change in the postoperative UCVA. Therefore, the trend in reducing corneal incision sizes below 2.8 mm might not be contributing the surgical outcomes of the patients, especially when we consider potential corneal endothelial changes.

Keywords: Endothelial cell count; microincisional cataract surgery; standard incision cataract surgery; surgically induced astigmatism.

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Cataract surgery is constantly renewing itself. Phacoemulsification cataract surgery provides better postoperative refractive outcomes compared to extracapsular cataract surgery techniques [1]. Nowadays, cataract surgery is considered as a refractive surgery rather than a procedure performed just to prevent blindness [2]. One of the most important refractive outcomes of this surgery is residual astigmatism. To reduce postoperative residual astigmatism, corneal incision sizes were decreased 3.2 mm to microincisions

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as small as 1.2 mm [3]. There are two factors that limit corneal incision size. First, a sufficient fluid current is needed around the phaco tip for protecting cornea from thermal damage. Second, the incision should also allow safe implantation of an intraocular lens. Therefore, the most commonly preferred current corneal incision sizes are 2.8 mm and 2.2 mm incisions.

The main shortcoming of the phacoemulsification technique is slightly increased rate of endothelial loss and risk of pseudophakic bullous keratopathy compared to extracapsular cataract surgery [1]. Intracameral high-shearing rate jet streams and thermal damage due to ultrasound energy are the main factors that cause endothelial damage. Different phaco tips (straight, kelman, and balance) and different phaco modes (longitudinal, transversal, and torsitional) were developed to reduce the energy needed during phacoemulsification [4, 5]. Different corneal incision sizes may end up with different fluidics dynamics and 2.2 mm systems may show to cause more endothelial damage compared to 3.0 mm systems probably due to higher jet streams and difficulties during intraocular manipulations [6].

The aim of the current study was to compare endothelial loss, the amount of the used ultrasound energy and surgically induced astigmatism in patients that had phacoemulsification cataract surgery with microincisional (2.2 mm) and standard incision (2.8 mm) phaco systems.

MATERIALS AND METHODS

This prospective, randomized, and comparative study consisted of patients with senile cataracts who applied to Istanbul Medeniyet University Faculty of Medicine, Department of Ophthalmology. Patients that had a history of ocular surgery, chronic eye disease, or comorbidities that complicated the cataract surgery (e.g., corneal scarring, small pupil, narrow anterior chamber, exfoliation syndrome, and glaucoma) were excluded from the study. The study protocol was approved by the Ethics Committee of the Istanbul Medeniyet University, Goztepe Prof. Dr. Suleyman Yalcin City Hospital (Number: 2019/0394). All of the participants gave a written informed consent and the study protocol adhered to the tenets of the Declaration of Helsinki.

The patients were randomly allocated to microincisional (2.2 mm) cataract surgery and standard incision (2.8 mm) cataract surgery groups. Respective phaco sleeves were used for mircoincisional (Alcon Infiniti MicroSmooth, 0.9 mm, Ultra Sleeve for 2.20 mm incision size) and standard incision (Alcon Infiniti MicroSmooth, 0.9 mm Sleeve for 2.75 mm incision size) systems. All patients were operated by the same surgeon (EBK) to exclude interoperator differences. The same ophthalmic viscosurgical devices (OVD) were preferred in all cases. The preferred dispersive OVD was 3.0% sodiumhyaloronate (Crownvisc 3.0%, Miray Medikal, Bursa, Turkiye) during capsulorhexis and phacoemulsification. A cohesive OVD (1.4% sodiumhyaloronate, HealonGV, Johnson and Johnson Vision, Inc., USA) was preferred during IOL implantation.

A detailed ophthalmologic examination was performed including determination of uncorrected visual acuity by Snellen chart, slit lamp examination, and dilated fundus examination with indirect ophthalmoscopy. Pre-operative and post-operative 1st week endothelial cell counts of all patients were measured by specular microscopy (Tomey EM-4000, USA)and corneal astigmatism values were measured with the keratometer of our optical biometry (LENSTAR LS900 Haag-Streit, USA) before and after surgery. Cataract grades were evaluated and recorded according to lens opacities classification system (LOCS III).

The surgeries were performed with the Alcon Infiniti Ozil Intelligent Phaco Vision system and cumulative dissipated energy (CDE) was automatically calculated by the device. 0.9 mm 45 degree ABS Kelman miniflared phaco tips were used in all surgeries. All surgeries were performed under proparacaine 0.5 % topical anesthesia (Alcain, Alcon, Forth Woth, TX) and stop and chop technique was preferred. All clear corneal incisions were performed at 11 o'clock position either with a 2.2 mm or 2.8 mm disposable steel blade (Sharpoint™, Caliber Ophthalmics, China). Corneal incisions were closed with stromal hydration and none of the patients needed corneal sutures for wound closure.

Highlight key points

- Induction of surgically induced astigmatism (SIA) was slightly more in standard incision cataract surgery compared to microincisional cataract surgery.
- Endothelial loss tended to be less following standard incision cataract surgery compared to microincisional cataract surgery.
- There was no significant difference between standard incision cataract surgery and microincisional cataract surgery, while there was tendency for less SIA induction in microincisional cataract surgery and better endothelial protection in standard incision cataract surgery.

TABLE 1. Demographic characteristics and visual acuity of study groups

	Standard incision group	Microincisional group	p
Age	70.70±8.44	66.71±9.37	0.09*
Patient/Eye	28/30	28/31	
Gender (M/F)	10/18	15/13	0.18[a]
Pre-op vision			
Mean±SD	0.600±0.318	0.530±0.308	0.45″
Post-op vision			
Mean±SD	0.204±0.268	0.121±0.136	0.27″
P[1]	<0.001[#]	<0.001[#]	–
NSG			
Mean±SD	1.97±0.76	1.87±0.61	0.79″
CDE (mJ)			
Mean±SD	5.90±3.69	5.61±3.39	0.70″

Vision: logMar; NSG: Nuclear sclerosis grade; CDE: Cumulative dissipated energy; P[1]: Statistical analysis of the change between post-op vision and pre-op vision; *: T-test; ″: Mann–Whitney U test; #: Wilcoxon test; a: Chi-Square test; SD: Standard deviation.

TABLE 2. Vector analysis of corneal astigmatism

	Standard incision group	Microincisional group	p
Pre-op CA			
Mean±SD	-0.92±0.50	-0.79±0.62	0.19″
Post-op CA			
Mean±SD	-0.83±0.46	-0.90±0.51	0.52″
P1	0.271[a]	0.144[a]	–
TIA			
Mean±SD	0.92±0.50#/0.14*	0.79±0.62#/0.19*	0.19″
SIA			
Mean±SD	0.78±0.57#/0.47*	0.61±0.39#/0.37*	0.30″
Axis of SIA			
Mean±SD	68.30±40.74#/64°	67.67±35.83#/61°	0.88″
DV			
Mean±SD	0.83±0.46#/0.33*	0.90±0.51#/0.52*	0.52″

CA: Corneal astigmatism; TIA: Target induced astigmatism; SIA: Surgically induced astigmatism; DV: Difference vector; P[1]: Statistical analysis of the change between post-op CA and pre-op CA; *: Vector mean; #: Arithmetic mean; ″: Mann-Whitney U test; a: Wilcoxon test; SD: Standard deviation.

Astigmatic Vector Analysis

Pre-operative and post-operative astigmatism magnitude of the patients were measured and then vector analysis was performed with the help of a fully automated software (AstigMATIC) using the Alpins method [7]. Target induced astigmatism (TIA) vector, surgically induced astigmatism (SIA) vector, and difference vector (DV) values were recorded from the final analysis. TIA graph demonstrates the magnitude and axis of the induced astigmatism that was calculated or expected to occur at the beginning of the surgery. SIA graph represents the magnitude and axis of the astigmatism that was induced postoperatively. DV graph represents the postoperative astigmatism value of the patient that remained after the surgery [7].

Statistical Analysis

The statistical analyses were performed with SPSS 21.0 software for mac (IBM Corp., Chicago, IL, USA). The distribution of the data was evaluated by Shapiro–Wilk test. Normally distributed data was compared with Student's t-test between the groups and data without normal distribution was compared with Mann–Whitney test. The Chi-square test was used to compare gender distribution between the groups. Repeated measures were compared with Wilcoxon test. P values below 0.05 were considered statistically significant.

RESULTS

Sixty one eyes of 56 patients who applied to Istanbul Medeniyet University Faculty of Medicine, Department of Ophthalmology due to senile cataracts were included in our study. Microincisional cataract surgery (2.2 mm) was performed to 31 eyes of 28 patients and standard incisionsurgery (2.8 mm) was performed to 30 eyes of 28 patients. Age and gender distributions were similar between the groups (p=0.09 and p=0.18, respectively). None of the patients had any intraoperative or post-operative complication. Nuclear sclerosis grade was similar between the groups (p=0.79) and similar levels of ultrasound energy were used in both groups (p=0.70). Pre-operative and post-operative visual acuities were similar in both groups (p=0.45 and p=0.27, respectively). Post-operative visual acuity increased significantly both in microincision and standard incision groups (p<0.001 and p<0.001, respectively). The clinical and demographic characteristics of the patients are listed in Table 1.

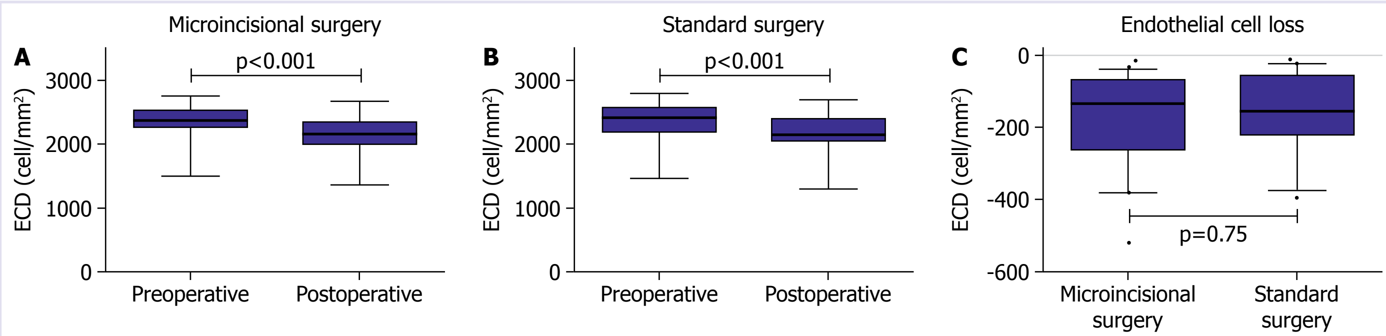

Figure 1. Endothelial changes following microincisional and standard incision phacoemulsification cataract surgeries. Endothelial cell count decreased significantly following both microincisional cataract surgery **(A)** and standard incision cataract surgery **(B)**. Endothelial cell loss was slightly more in microincisional cataract surgery compared to standard incision surgery, while this difference was not statistically significant **(C)**.

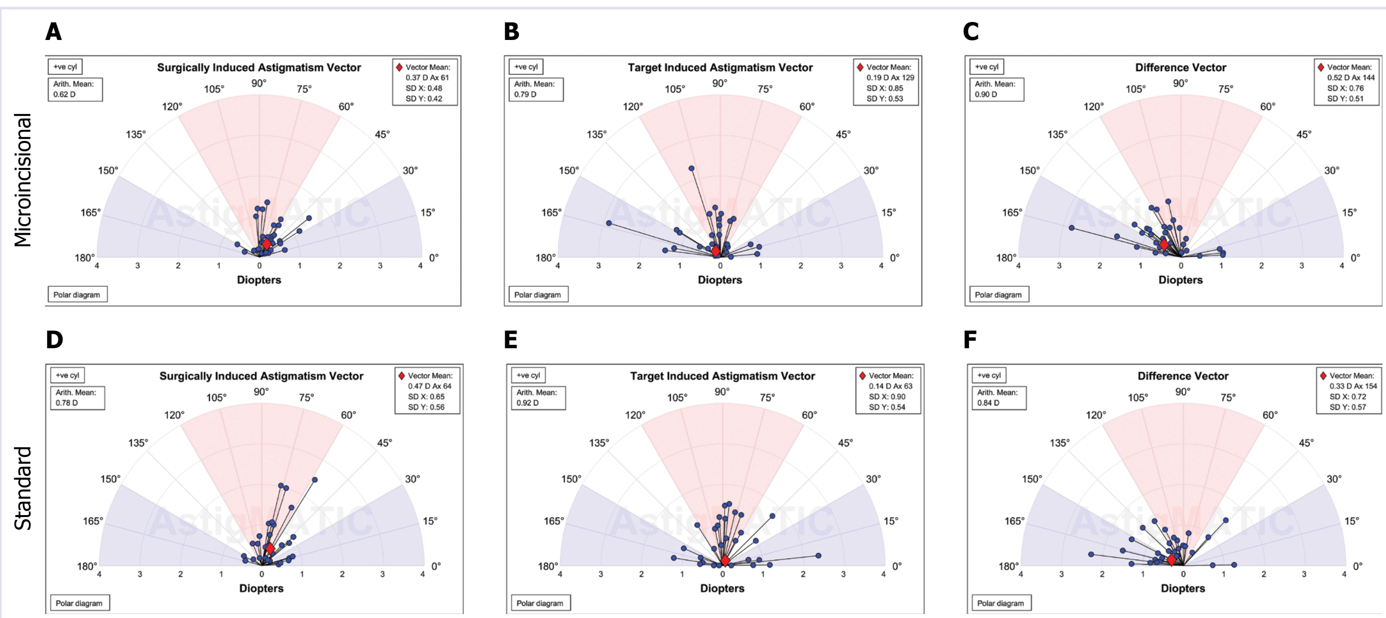

Figure 2. Surgically induced astigmatism changes following microincisional and standard incision phacoemulsification cataract surgeries. Surgically induced astigmatism (SIA) vectors, target induced astigmatism vectors and difference vectors were shown for microincisional surgery group **(A–C)** and standard incision surgery groups **(D–F)**. Although SIA was slightly higher in standard incisional surgery, this difference was not statistically significant.

Endothelial cell density decreased significantly both in microincisional group (2324.74±312.31 vs. 2149.87±288.82, p<0.001) and in standard incision groups (2359.95±292.40 vs. 2199.11±317.71, p<0.001). Endothelial cell loss was slightly lower in the standard incision group compared to microincisional group (160.84±121.58 vs. 174.87±132.27), but this difference was not statistically significant (p=0.75). The details of the endothelial changes are shown in Figure 1.

Pre-operative corneal astigmatism values were similar between the microincision and standard incision groups (p=0.19). Vector analysis revealed that SIA was slightly higher in the standard incision group compared to microincision groups (0.47 day vs. 0.37 day), but this difference was not statistically significant (p=0.30). There was also no statistically significant difference between the groups for final uncorrected visual acuity (p=0.27). The outcomes of the astigmatic vector analyses are shown in Figure 2. The details of the vectorial and arithmetic changes in astigmatism values are shown in Table 2.

DISCUSSION

Smaller corneal incisions were shown to reduce postoperative corneal astigmatism following cataracts surgery and the most commonly preferred corneal incisions became smaller over time. Many surgeons choose smaller incisions instead of 3.2 mm to reduce post-operative astigmatism and 2.8 mm corneal incisions became the standard approach in many centers. The availability of 2.2 mm phacoemulsification systems lead some of the centers to prefer mircoincisional cataract surgery. There are also smaller incision options (e.g., 1.8 mm, 1.5 mm, and 1.2 mm), but these microincisional surgeries can only be performed with certain instruments and limited number of intraocular lenses can be implanted through these incisions. The limited number of IOL options (especially for premium IOLs) and instruments prevented widespread use of these very small incision phacoemulsification systems. The most commonly preferred corneal incision sizes are 2.8 mm and 2.2 mm in current routine cataract surgery. There are many studies that compared the effect of large corneal incisions and very small incisions on postoperative corneal astigmatism following phacoemulsification cataract surgery. The current study provided comparative data on the influence of 2.8 and 2.2 corneal incisions on postoperative corneal astigmatism and endothelial cell loss.

SIA induction was significantly more in the patients operated with 3.2 mm incisions compared to 2.2 mm and 1.8 mm incisions, while there was no significant difference in SIA induction between the 2.2 mm and 1.8 mm groups [8]. A comparison of SIA outcomes following surgeries performed with 3.0 mm and 2.2 mm incisions also demonstrated that SIA was significantly reduced in patients operated with 2.2 mm incisions, while patients operated with 1.8 mm incisions did not induce a significant difference in SIA compared to 2.2 mm incisions [6]. Other studies comparing microincisional surgeries with 2.2 mm and 1.8 mm incisions also did not find a significant difference [9, 10], except for one [11]. However, the authors emphasized that this difference was not clinically relevant despite the statistical significance, while the difference between the 3.0 mm and microincisional groups was both statistically and clinically significant. He et al. [2] compared the 2.8 mm small incision cataract surgery with 1.8 mm mircoincisional cataract surgery and this study revealed that anterior corneal SIA was significantly higher in 2.8 mm group compared to 1.8 mm group (0.59 day vs. 0.37 day). Although statistically significant, this difference was also not clinically relevant. The current study compared the results of the more commonly preferred 2.2 mm mircoincisional cataract surgery with 2.8 mm standard incision cataract surgery and there was a trend toward a higher induction of SIA in 2.8 mm group compared to 2.2 mm, but this difference was not statistically significant unlike the above-mentioned studies with a larger incision size difference between the study groups. There are also two relatively-new studies, that compared the impact of 2.8 mm and 2.2 mm incisions on SIA and they also confirmed our observations that decreasing corneal incision size from 2.8 mm to 2.2 mm did not significantly affect SIA [12, 13]. We understand from the above mentioned studies that different corneal incision sizes have different impacts on corneal biomechanics. Therefore, the difference between 3.2 and 2.2 mm incisions cannot help us to predict the outcome with different incision sizes (e.g., 2.8 mm vs. 2.2 mm).

Corneal endothelial cell loss is an important complication of phacoemulsification cataract surgery and can lead to serious complications such as bullous keratopathy. Studies comparing standard small incision cataract surgery and mircoincisional surgery demonstrated no significant difference in endothelial loss [2, 6, 11, 14]. while some of them found an insignificant trend toward a higher endothelial cell loss in smaller incision sizes [10]. Two studies that compared the impact of 2.8 and 2.2 mm corneal incision sizes on endothelial loss demonstrated that microincisional surgery had an insignificant trend toward more endothelial loss although this small differences were not statistically significant [12, 13]. Smaller incisions tend to cause more or faster jet streams and might not cool down the phaco tip efficiently compared to larger incisions that have a larger phaco sleeves with a higher amount of fluid surrounding and cooling down the phaco tip. We suspect that reduced jet streams and subsequent sheer force might have reduced endothelial cell loss in standard incision group. A meta-analysis of the studies comparing endothelial cell count in standard incision and microincisional cataract surgeries demonstrated that there was no significant difference in endothelial cell loss between standard incision and microincisional cataract surgeries [15]. The current study also confirmed the above-mentioned observations that phacoemusification with a 2.8 mm corneal incision induced slightly more endothelial loss compared to 2.2 mm corneal incisions and this difference was not statistically significant. Endothelial cell loss showed a very high interindividual variation following cataract surgery both in the previous studies and in the current study. Therefore, the detection of very subtle influences of the surgical approaches might not be always possible despite certain trends favoring higher endothelial loss in microincisional surgery. It might be safer to prefer 2.8 mm incision size in patients with pre-operative reduced endothelial cell counts, but this small difference in endothelial cell loss does not seem to be relevant in most of the cases with healthy corneas.

This study had several limitations. First, the post-operative enlargement of the corneal incisions was not evaluated in the groups. The previous work on microincisional cataract surgery demonstrated that around 0.2 enlargement of the corneal incision is likely to occur in these cases [10]. Different locations of the corneal incisions induce different magnitudes of SIA and all of the corneal incisions were performed at 11 o'clock position for standardization purposes. The outcomes of this study might not reflect SIA induced in other corneal quadrants. In the current study, the duration of surgery and total phacoemulsification time was not evaluated, but there was no difference between the two groups in terms of CDE which can influence the endothelial cell count. All of the surgeries were performed by the same phaco instrument, phaco tip, and surgeon for standardization purposes. Some of the previous studies used different phaco systems or tips for microincisional and standard incision cataract surgeries [2, 6]. Different pump systems in different instruments can induce different magnitudes of jet streams and different phaco handpieces or phaco tips may spend variable amounts of energy during phacoemulsification.

This study demonstrated that standard incision cataract surgery tended to induce slightly more SIA compared to microincisional cataract surgery, but this difference was not statistically significant. In addition, standard incision cataract surgery also tended to induce less endothelial cell loss compared to microincisional cataract surgery, but this difference was also not statistically significant. The current data indicated that the outcome of these surgeries was relatively similar and reducing the corneal incision size from 2.8 mm to 2.2 might not bring an important advantage for the patient. The preference of the surgeon and individual needs of the patients seem to be more important while selecting between these corneal incision sizes, as there is no strong proof of superiority neither in favor of 2.2 mm nor 2.8 mm corneal incisions.

Ethics Committee Approval: The Istanbul Medeniyet University Clinical Research Ethics Committee granted approval for this study (date: 09/10/2019, number: 2019/0394).

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REFERENCES

1. Pershing S, Kumar A. Phacoemulsification versus extracapsular cataract extraction: where do we stand? Curr Opin Ophthalmol 2011;22:37–42.
2. He Q, Huang J, Xu Y, Han W. Changes in total, anterior, and posterior corneal surface higher-order aberrations after 1.8 mm incision and 2.8 mm incision cataract surgery. J Cataract Refract Surg 2019;45:1135–47.
3. Donnenfeld ED, Olson RJ, Solomon R, Finger PT, Biser SA, Perry HD, et al. Efficacy and wound-temperature gradient of whitestar phacoemulsification through a 1.2 mm incision. J Cataract Refract Surg 2003;29:1097–100. [CrossRef]
4. Ataş M, Demircan S, Karatepe Haşhaş AS, Gülhan A, Zararsız G. Comparison of corneal endothelial changes following phacoemulsification with transversal and torsional phacoemulsification machines. Int J Ophthalmol 2014;7:822–7.
5. Demircan S, Ataş M, Göktaş E, Başkan B. Comparison of 45-degree Kelman and 45-degree balanced phaco tip designs in torsional microcoaxial phacoemulsification. Int J Ophthalmol 2015;8:1168–72.
6. Luo L, Lin H, He M, Congdon N, Yang Y, Liu Y. Clinical evaluation of three incision size-dependent phacoemulsification systems. Am J Ophthalmol 2012;153:831–9.e2. [CrossRef]
7. Gauvin M, Wallerstein A. AstigMATIC: an automatic tool for standard astigmatism vector analysis. BMC Ophthalmol 2018;18:255.
8. Febbraro JL, Wang L, Borasio E, Richiardi L, Khan HN, Saad A, et al. Astigmatic equivalence of 2.2-mm and 1.8-mm superior clear corneal cataract incision. Graefes Arch Clin Exp Ophthalmol 2015;253:261–5.
9. Lee KM, Kwon HG, Joo CK. Microcoaxial cataract surgery outcomes: comparison of 1.8 mm system and 2.2 mm system. J Cataract Refract Surg 2009;35:874–80. [CrossRef]
10. Vasavada V, Vasavada AR, Vasavada VA, Srivastava S, Gajjar DU, Mehta S. Incision integrity and postoperative outcomes after microcoaxial phacoemulsification performed using 2 incision-dependent systems. J Cataract Refract Surg 2013;39:563–71. [CrossRef]
11. Yu YB, Zhu YN, Wang W, Zhang YD, Yu YH, Yao K. A comparable study of clinical and optical outcomes after 1.8, 2.0 mm microcoaxial and 3.0 mm coaxial cataract surgery. Int J Ophthalmol 2016;9:399–405.
12. Sethi HS, Saluja K, Naik MP. Comparative analysis of coaxial phacoemulsification with 2.2- and 2.8-mm clear corneal incisions. Int Ophthalmol 2018;38:215–22. [CrossRef]
13. Hashemi H, Zandvakil N, Rahimi F, Beheshtnejad AH, Kheirkhah A. Clinical comparison of conventional coaxial phacoemulsification and coaxial microincision phacoemulsification. Iran J Ophthal 2010;22:13–24.
14. Mencucci R, Ponchietti C, Virgili G, Giansanti F, Menchini U. Corneal endothelial damage after cataract surgery: Microincision versus standard technique. J Cataract Refract Surg 2006;32:1351–4. [CrossRef]
15. Wang L, Xiao X, Zhao L, Zhang Y, Wang J, Zhou A, et al. Comparison of efficacy between coaxial microincision and standard-incision phacoemulsification in patients with age-related cataracts: a meta-analysis. BMC Ophthalmol 2017;17:267. [CrossRef]