ABSTRACT

A comparison of the integrity of clear corneal incision wound and induced corneal astigmatism according to the material of keratome and the size of incision

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Purpose : To compare wound characteristics and morphologic and optical integrity of clear corneal incision formed with a 2.8-mm metal blade or 2.8-mm or 3.2-mm incisions formed by diamond blades.

Design : Prospective, randomized clinical study.

Methods : Patients who underwent phacoemulsification with intraocular lens implantation through temporal clear corneal incision (CCI) were randomized into 1 of 3 groups, i.e. a 2.8-mm metal blade (MB), and either 2.8-mm or 3.2-mm diamond blade (DB) group. The incisions were evaluated at 1 day, 1 week, and 1 month after surgery for coaptation of incision and wound architecture using RTVue Fourier-domain optical coherence tomography. Vision and autokeratometry were also measured to evaluate surgically induced astigmatism (SIA) at postoperative 1 month.

Results : There was no difference in the incidence of epithelial gaping among groups, but the length of epithelial gaping was larger in 2.8mm MB group at

postoperative 1 day. Gaping at the endothelial side of the wound was persistent more frequently until post operative 1 month in 2.8mm DB group than other groups. Endothelial bullae was observed more frequently at 1 week after surgery in 2.8mm DB group than other groups. In the aspect of quality of incision angle, there was no difference among groups in 1 month, but 3.2mm DB made significantly steeper angle than the other two types of 2.8mm blades at postoperative 1 week. There were no significant differences in corneal thickness at central part of CCI, but at nasal and temporal part of CCI site, CCI created by 2.8mm DB showed thicker corneal thickness than the other groups for a week. The mean SIA using vector analysis was larger in the 3.2mm diamond group than other groups.

Conclusion : After phacoemulsification, CCI made by DB showed more corneal edema and reduced internal CCI structural integrity than CCI made by MB in 2.8mm incision size. 2.8 mm incision compared to 3.2 mm incision, result in less SIA regardless of the material of microkeratome.

Key words : clear corneal incision, diamond blade, fourier-domain optical coherence tomography, metal blade, wound integrity

I. INTRODUCTION

Clear corneal incisions (CCIs) are the most popular type of incision used in modern-day phacoemulsification cataract surgery.[1, 2] They are relatively easier and faster to create than scleral tunnel incisions and, unlike limbal incisions, they provide a bloodless operative field. If constructed properly, they can be effectively sealed without a suture and produce minimal iatrogenic astigmatism. Postoperatively, they usually provide fast visual recovery with an associated high degree of patient satisfaction. Over the past decade, however, the incidence of endophthalmitis after cataract surgery has increased.[3–5] There has been much debate on whether the increasing use of CCIs has contributed to this.[6–10] A recent meta-analysis of the literature speculated that the integrity of CCIs during the postoperative period may be a critical factor in predicting endophthalmitis.[11]

Experimental evidence examining the integrity of CCIs in vivo is limited. The imaging technique of optical coherence tomography (OCT) can be used to examine the internal architecture of CCIs.[12] Recently, anterior segment specific OCT imaging systems, such as the Visante (Carl Zeiss Meditec, Jena, Germany) time-domain OCT system have been used. The noncontact Visante is quick and easy to use, and safe for the patient. With these qualities, it lends itself well to examining postoperative eyes. Recently, Fine et al,[13] Calladine and Packard,[14] and Xia et al[15] have used the Visante to examine CCIs 1 hour, 24 hours and 72 hours after cataract surgery. The images obtained clearly

demonstrate the bidimensional profile of CCIs, allowing accurate measurement of parameters such as incision length, angle, epithelial gaping, endothelial gaping, endothelial misalignment, local detachment of Descemet's membrane, and loss of coaptation.

Unsutured clear corneal incisions have been shown to induce changes from presurgical astigmatism, the extent of which varies with several factors, the most significant being incision width.[16,17] There has been a general trend toward reducing incision size, although the absolute size for a cataract incision that causes the least amount of astigmatism has not been established.

To our knowledge, RTVue Fourier-domain optical coherence tomography (Optovue, Inc., Fremont, CA) has not been used to examine CCIs in vivo. Our principle aim was therefore to investigate the architecture of CCIs within a month of completing cataract surgery using RTVue. By varying the width and material of blade, we also aimed to compare wound architecture and surgically-induced astigmatism based on these variables.

II. MATERIALS AND METHODS

This is a prospective, randomized clinical study conducted at the Eye Center of Shinchon Severance Hospital, and the Institutional Review Board approved the study protocol. Patients who had no ocular pathologic features other than cataracts and planned to receive phacoemulsification with intraocular lens (IOL) implantation were recruited to participate in this study. Using a random

number table, patients were randomly assigned to one of the following groups, consisting of clear corneal incisions of different sizes made with blades of different materials, i.e. 2.8mm incision with a metal blade (2.8mm MB group) and 2.8mm or 3.2mm with diamond blades (2.8mm DB group and 3.2mm DB group).

We collected the patients' demographic data and records of past ocular, systemic, and medical histories. Inclusion criteria were: age between 40 and 80 years, no history of eye surgery or glaucoma, a transparent central cornea, absence of biomicroscopic signs of pseudoexfoliation, and normal fundus examination.

Exclusion criteria were: eyes with more than 2.00 diopters (D) of astigmatism (to exclude eyes in which astigmatic incisions would be necessary), and other ocular diseases that might affect visual outcomes (eg, color vision disturbance, chronic uveitis) or contrast sensitivity function (high myopia, glaucoma, maculopathy). Eyes with intraoperative complications such as posterior capsule rupture or zonular injury and requiring a corneal suture for closure of the incision were excluded at the end of surgery, and patients who lacked follow-up for one month were also counted out of this study.

Preoperative standard comprehensive ophthalmic examination was recorded for all patients. The examination included clinical data, the refractive status of the eye, uncorrected visual acuity (UCVA) and best spectacle-corrected

distance visual acuities (BSCVA) using Snellen charts, slit lamp evaluation, autokeratometry and intraocular pressure (IOP) measurement by noncontact tonometry.

All the surgeries were performed by the same surgeon (T.I.K) using a temporal, clear corneal incision under topical anesthesia. A side-port incision was made, and the anterior chamber was filled with viscoelastic material. A 2.8mm metal or diamond blade or a 3.2mm diamond blade was used to form a corneal incision of the each size. After continuous curvilinear capsulorhexis and hydrodissection, an in situ phacoemulsification was performed using either the 'divide and conquer' technique or the 'phaco chop' technique. The Sovereign Whitestar Technology (Advanced Medical Optics, Inc., Santa Ana, CA) was applied for the phacoemulsification of nuclear fragments, with parameters set as follows: Ellips™ Transversal mode with 100% amplitude, vacuum of 360 mmHg, flow rate of 36 mL/min, and bottle height of 100 cm. The phaco tip with a 30-degree bevel and standard sleeves were used. An injector system was used for in-the-bag implantation of IOLs, but in no case was it necessary to widen the original incision. The model of IOLs inserted was TECNIS™ ZA9003 in all 3 groups. The incision was sealed with stromal hydration. At the end of the procedure, the wound was checked for leakage.

After one day, one week, and one month, the following postoperative examinations were performed: visual acuity, IOP, slit lamp examination, and analysis of the corneal incision using RTVue OCT. Time-dependent changes

in surgically induced astigmatism (SIA) and incision configuration were assessed.

All the RTVue images of the main incisions were examined for the presence of wound gape. Both external and internal gapes were recorded, and Descemet's membrane detachment (DMD) and endothelial bullae, when present, were also recorded (Figure 1). The thickness of the main incision was measured at the midpoint, 1mm nasal and 1mm temporal side of the wound. The angle of the incision, which is the angle formed between the line joining the epithelial and endothelial edges and the tangent line to the epithelial edge of the incision (Figure 2). When corneal epithelial defects were present, the lengths of the defects were measured by counting the number of defect cuts on RTVue.

Surgically induced astigmatism was calculated using vector analysis methods. Vector analysis treats cylinder as a vector with magnitude and direction. The refractive error is expressed in sphere/cylinder × axis format. Two or more vectors can be compared with these techniques. In this study, SIA was determined using a free online SIA calculator that uses the Holladay method of vector analysis.[18,19]

Statistical analysis was performed using SPSS software version 13.0 (SPSS, Inc., Chicago, Illinois, USA), and statistical significance was set at $P < .05$.

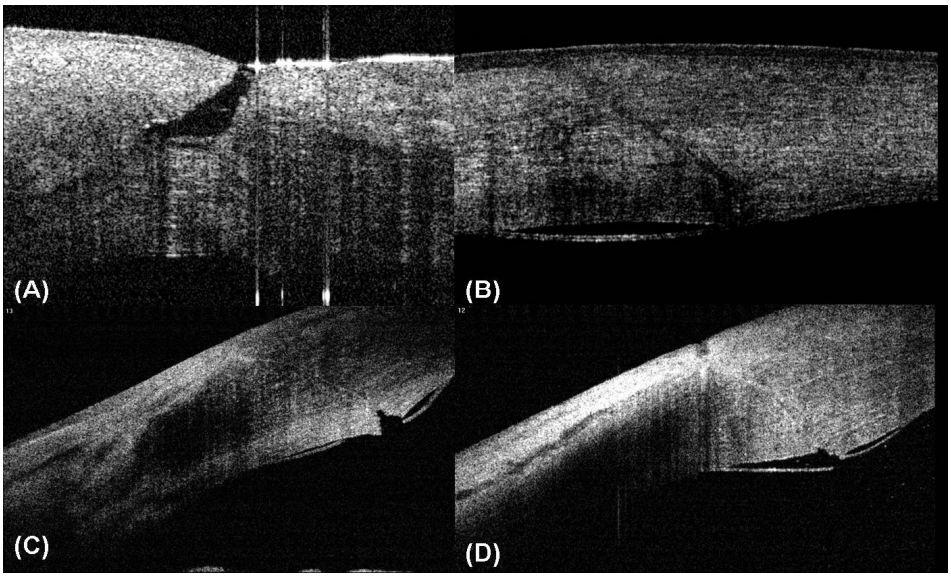

Figure 1. (a) RTVue image of CCI showing gaped epithelial edge and epithelial gaping, (b) endothelial bullae, (c) endothelial gaping, (d) Descemet's membrane detachment.

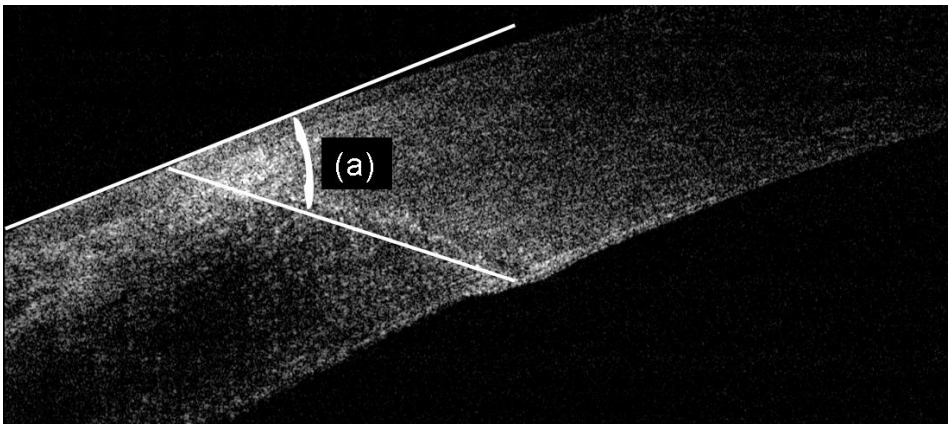

Figure 2. RTVue image of a CCI showing the model used in the study for measuring angle of the incision (a) formed between the line joining the epithelial and endothelial edges and the tangent line to the epithelial edge of the incision.

III. RESULTS

Sixty-two eyes of 54 patients (23 women, 31 men) were enrolled in this study. The mean patient age was 64.3 years (range: 45 to 87 years). Table 1 shows the patients' characteristics and postoperative outcomes by group.

Table 1. Patient characteristics and postoperative outcomes by group.

Parameter	Group			
	2.8mm MB	3.2mm DB	2.8mm DB	p-value
Patients (n)	26	12	16	
Eyes (n)	30	15	17	
Sex, n (%)				
Female	11 (42)	3 (25)	9 (56)	
Male	15 (58)	9 (75)	7 (43)	
Mean age ± SD (years)	61.40±8.03	66.38±2.83	65.28±6.65	
Mean postoperative 1 month BSCVA ± SD	0.85 ±0.07	0.84 ±0.12	0.89 ±0.09	0.25
Mean postoperative 1 month Mean SE ±SD	-0.70 ±0.38	-0.45 ±0.26	-0.45 ±0.44	0.16
Mean IOP (mmHg) ± SD				
1 day	14.32 ± 4.4	15.33± 3.9	15.66±4.32	0.50
1 week	13.88 ±2.64	14.26±3.64	14.33±4.23	0.62
1 month	13.75 ± 2.77	14.01±2.31	14.23 ±3.59	0.43

Kruskal-Wallis test

BSCVA=best spectacle-corrected distance visual acuity; SD=standard deviation; SE=spherical equivalent.

1. Configuration of incision

Changes on the epithelial side of the wound

Epithelial gaping at the site of the incision was seen in 46.7% of the 2.8mm MB group, 26.7% of the 3.2 mm DB group and 35.3% of the 2.8 mm DB group at postoperative 1 day (p=0.406, Fisher's exact test). There were no epithelial defects at postoperative one week and one month in any of the groups. When epithelial gaping was present, the number of defect cuts on RTVue (the lengths of epithelial gaping) were 2.3± 0.82 in the 2.8mm MB group, 1.8 ± 0.95 in the 3.2 mm DB group and 1.2 ± 0.75 in the 2.8 mm DB group (p=0.044, Kruskal-Wallis test). Subsequent pairwise comparisons revealed a significantly larger number of defects in the 2.8mm MB group than in the 2.8mm DB group (p=0.011; Mann-Whitney test, Bonferroni corrected).

The average angle of the incision

The average angle of the incision relative to the tangent plane to the corneal surface was different among the groups at post operative one day and one week (Table 2). Subsequent pairwise comparisons revealed a significantly more acute angle of incision in the 3.2mm DB group than in the 2.8mm DB or 2.8mm MB groups (p=0.013, 0.009 in postoperative 1 day, p=0.031, 0.031 in postoperative 1 week; Mann-Whitney test, Bonferroni corrected). This difference disappeared at postoperative 1 month (Table 2).

Table 2. Incision angle (in degrees) of the 3 groups at postoperative 1 day, 1 week and 1 month.

	Group			
Incision angle (degrees ±SD)	2.8mm MB	3.2mm DB	2.8mm DB	p-value
Post-operative 1 day	44.3 ±3.65	48.6 ±5.06	43.6 ±5.35	0.005
Post-operative 1 week	42.35±2.71	45.81±4.31	41.92 ±5.77	0.016
Post-operative 1 month	40.7 ±2.74	43.3 ±4.26	41.54 ±4.65	0.107

Kruskal-Wallis test
SD=standard deviation

Apposition of the endothelial side of the wound

Gaping at the endothelial side of the wound was found in almost all cases in all three groups. Gaping was persistent until postoperative one week, but disappeared by postoperative one month, except in the 2.8mm DB group. Subsequent pairwise comparison revealed significantly higher incidence of endothelial gaping in the 2.8mm DB group than in the 2.8mm MB group (p=0.039; Fisher's exact test; Bonferroni corrected). There was no difference between 2.8mm DB and 3.2mm DB groups. Endothelial bulging was observed more frequently in 2.8 mm DB group than in the 2.8mm MB or 3.2mm DB group until postoperative one week (p=0.003, 0.039 in postoperative 1day, p=0.000, 0.000 in postoperative 1 week; Fisher's exact test; Bonferroni corrected) (Table 3).

Descemet's membrane detachment

No patients were found to have DMD by routine slit-lamp microscopy on postoperative day one. However, DMD was very frequently observed using RTVue. There was no difference in the incidence of DMD among the three groups until post operative one month (Table 3).

Table 3. Endothelial gaping, bullae and Descemet's membrane detachment in 3 groups at postoperative 1 day, 1 week and 1 month.

Parameter	Group			p-value
	2.8mm MB	3.2mm DB	2.8mm DB	
Endothelial gaping (%)				
Postoperative 1 day	100.0	100	94.1	0.260
Postoperative 1 week	96.7	93.3	94.1	0.862
Postoperative 1 month	0	6.7	23.5	0.017*
Endothelial bullae (%)				
Postoperative 1 day	43.3	53.3	94.1	0.003*
Postoperative 1 week	16.7	5.6	77.8	0.000*
Postoperative 1 month	0	0	9.4	0.065
DM detachment (%)				
Postoperative 1 day	93.3	86.7	94.1	0.687
Postoperative 1 week	66.7	66.7	82.4	0.479
Postoperative 1 month	0	0	11.8	0.075

Fisher's exact test
*$p < 0.05$
DB=diamond blade; DM=Descemet's membrane; MB=metal blade.

Corneal thickness at the incision site

Corneal thickness (CT) at the center of incision site was not different among groups until postoperative one month; however, the CT measured at 1mm nasal from incision differed between the groups until postoperative one month. Subsequent pairwise comparison revealed significantly thicker CT in the 2.8mm DB group than in the 2.8mm MB or 3.2 mm DB groups (p=0.000,

0.000 at postoperative 1 day, p=0.039, 0.006 at post operative 1 week, p=0.045, 0.039 at post operative 1 month; Mann-Whitney test, Bonferroni corrected). There was no difference between the 2.8mm MB and 3.2mm DB groups until postoperative one month. CT measured at 1mm temporal from the incision was different among groups until postoperative one week. Subsequent pairwise comparison revealed significantly thicker CT in the 2.8mm DB group than in the 2.8mm MB or 3.2 mm DB groups (p=0.031, 0.001 at postoperative 1 day, p=0.015, 0.003 at post operative 1 week) (Table 4).

Table 4. Corneal thickness (in ㎛) at incision in 3 groups at postoperative 1 day, 1 week and 1 month.

	Group			
location	2.8mm MB	3.2mm DB	2.8mm DB	p-value
Center of incision				
Postoperative 1 day	843.7±36.72	847.1±53.65	861.1 ± 106.20	0.434
Postoperative 1 week	817.4±40.51	819.6±50.53	836.4 ±77.67	0.510
Postoperative 1 month	767.1±44.30	775.3 ±51.89	748.8 ±57.86	0.302
1 mm nasal from incision				
Postoperative 1 day	795.1±43.15	806.0±56.51	893.1 ±45.83	0.000*
Postoperative 1 week	761.6 ±41.50	764.9 ±59.18	830.6 ±91.00	0.002*
Postoperative 1 month	714.0 ±51.40	703.4±49.92	759.5±67.57	0.011*
1 mm temporal from incision				
Postoperative 1 day	794.6±38.10	805.13±53.24	852.6 ± 65.92	0.001*
Postoperative 1 week	787.6 ±31.26	789.1 ±41.26	844.3 ±70.13	0.000*
Postoperative 1 month	756.0 ±46.64	752.9 ±48.33	762.4 ±49.01	0.152

Kruskal-Wallis test
*$p < 0.05$
DB=diamond blade; MB=metal blade.

2. Surgically induced astigmatism

Using vector analysis, the mean SIA was 0.67 ± 0.34 in the 3.2mm DB group, 0.46 ± 0.36 D in the 2.8mm DB group and 0.50 ± 0.28 D in the 2.8mm MB

group. The mean SIA was statistically significantly different between the three groups ($p<0.05$, Kruskal-Wallis test). In subsequent pairwise comparisons, the mean SIA of the 3.2mm diamond group was significantly higher than that of the 2.8mm DB group or the 2.8mm MB group ($p=0.010$, $p=0.013$, respectively; Mann-Whitney test with Bonferroni correction). There was no difference between the 2.8mm DB group and the 2.8mm MB group ($p>0.05$, Mann-Whitney test with Bonferroni correction).

IV. DISCUSSION

The quality of the incision has a great influence on the outcomes of cataract surgery; the more stable the configuration of the incision, the less trauma to the eye and thus the better the desired sealing effect. Incision size is a significant clinical factor in wound integrity and occurrence of SIA after phacoemulsification. It is widely accepted that the smaller the incision, the less SIA occurs.[20-21]

Traditionally, the first step in constructing a wound is choosing an available knife, either diamond or metal. Metal blades are not as sharp as diamond ones, and can cause surgeons to create less accurate and irregular incisions. Because metal blades meet more resistance from the cornea, however, they permit surgeons to gradually construct the incision with planned segments. Incisions made with a metal blade may be irregular, however, due to cicatrization. Diamond blades, being much sharper, produce more regular incisions faster, but the surgeon has less opportunity to change the direction of the cut if it was initially planned incorrectly. An overly short tunnel may result.[22-28]

RTVue is noncontact method using a CCD camera and a joystick. RTVue is the first Fourier-domain optical coherent tomography (OCT) system approved by the Food and Drug Administration. Similar to the Pentacam (Oculus, Inc., Wetzlar, Germany), RTVue does not induce any artificial changes to the cornea with drugs or mechanical contact. In addition, RTVue uses an advanced technology, which is a rapid imaging speed that overcomes eye

movement velocity and ensures 5-μm resolution and high magnification imaging of the cornea within 0.04 seconds. The high measurement velocity of RTVue is achieved with a stationary reference mirror. In older time-domain OCT systems, scan speed was limited because of the back-and-forth mechanical movement of a reference mirror over a range of several millimeters.[29] RTVue eliminates this mechanical restraint on speed by simultaneously collecting signals from the entire range of interest and analyzing data using the spectral interferogram and rapid Fourier transformation.[30] Despite the advantages of RTVue, there are no data estimating corneal incision with RTVue.

The self-sealing behavior of the wound is important as a barrier against intraocular infection. Several studies have attempted to correlate the dimensions of clear corneal incisions to functional wound sealing behavior.[11, 31, 32]

Taban et al[32] used OCT to observe wound gaping immediately after surgery in enucleated human and rabbit eyes under the conditions of varying intraocular pressure (IOP) and angles of the incision. They found that larger angles of incision (approaching 90°) tended to seal better under conditions of lower IOP, whereas incisions with a low angle of approach tended to seal better with a higher IOP. The angle of blade entry into the cornea has been shown to affect the self-sealing properties of the wound. At one extreme, an angle of 90°, or perpendicular to the wound, has almost no structural integrity

under physiologic conditions, whereas smaller angles of approach have been shown to be more effective at creating a self-sealing wound. A shallow angle gives the wound structural integrity, as the intraocular pressure would press the lower lip of the incision against the upper lip.[32] In our study, the angle of the incision was shallower in the 2.8mm metal and 2.8mm diamond groups than in the 3.2mm diamond group. This result suggests that incision size, rather than material of the blade, is more important in the self-sealing properties of the wound.

Retrospective analysis of CCIs in cases of postoperative endophthalmitis shows gaping and leaking of the main wound.[10,33] It is not possible to determine from these retrospective studies whether gaping of the wound predisposed to wound leaking and in turn to endophthalmitis. Fine and Hoffman[34] were among the first to recognize that without an intact epithelial layer, the corneal endothelium does not have the ability to help appose the roof and floor of the incision through hydrostatic forces. The role of the epithelium as a mechanical barrier and the physical properties of the anterior stroma, which constrain anterior swelling in the early architectural stability of CCIs, are areas that deserve further attention.[35, 36] In this study, malapposition of the edges of the anterior lip of the wound was seen in 46.7% of the 2.8mm MB group, 26.7% of the 3.2mm DB group and 35.3% of the 2.8mm DB group at postoperative one day, which is much higher than the result achieved by Torres et al.[12] Though the incidence of epithelial gaping was not different

between the groups, when epithelial gaping were present, the lengths of epithelial gaping were significantly smaller in the 2.8mm DB group than in the 2.8mm MB group. Because metal blades are not as sharp as diamond ones, surgeons may create less accurate and more irregular incisions.

In the early postoperative period, we found frequent imperfections in the posterior lip of the incision in all three groups, which were characterized by irregular endothelial bulging and gaping of endothelial edges. But in the late postoperative period, we found more frequent imperfections in the 2.8mm DB group than in the 2.8mm MB or 3.2mm DB groups. These anatomical imperfections might be related to the induced corneal edema of the posterior lip at the end of the surgery.[12] Efficient endothelial pumping may explain why apposition and gaping tend to improve over time. However, persistence of these irregularities might be related not only to stromal edema as a result of significant endothelial cell damage from direct mechanical trauma, ultrasound energy, and irrigating solution during the surgery but also to a more disorganized wound-healing response in the posterior stroma.[37-42] According to our study, imperfections in the posterior lip of the incision and persistent corneal edema were correlated with the incision size and the material of blade. A small incision with same phacoprobe may result in greater risks for unfavorable effects on surrounding tissue. In the manner of blade, though incisions made with a metal blade may be more irregular than with diamond blade, wound repair reaction might be faster and stronger due to cicatrization

as shown in this study.

Any surgical intervention on the cornea induces some degree of astigmatism. Previous studies have indicated that smaller incision size is associated with earlier stabilization of refraction[43] and that reduction of incision size can minimize SIA.[16, 17, 44] Because incisions made with a metal blade may be irregular due to cicatrization, we assumed that incisions made with a metal blade may cause much larger SIA. However, our study showed that only the incision size and not the material of blade had a main impact on SIA at postoperative 1 month.

V. CONCLUSION

In conclusion, we have shown that the RTVue imaging system is well suited to examine postoperative CCIs. The obtained images show the profiles of CCIs, allowing for the accurate measurement of parameters such as incision angle and thickness of corneal edema. The high-resolution images allow the identification of fine architectural features. The findings of the present study suggest important implications for cataract surgeons. The creation of a smaller incision size seems to lead to smaller incision angles which are more beneficial for wound apposition under the physiological condition. Moreover, compared to the metal blade, the 2.8mm diamond blade created decreased wound stability in the posterior lip of the incision and persistent corneal edema. Cataract surgeons should be aware of these variables when

constructing their wounds in order to achieve a well-sealed wound.

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ABSTRACT (IN KOREAN)

백내장 수술 시 투명각막절개창의 크기 및 각막 절개도의 재질에 따른 절개 단면 형상과 난시 변화의 비교

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목적: 백내장 수술 시 각막절개도의 재질 및 각막절개창의 크기에 따른 각막 절개면의 형태학적, 광학적 특징을 비교하고자 하였다.

방법: 투명 각막 절개를 이용하여 백내장 수술을 시행 받은 환자 64안 중 각막 절개창의 크기 및 각막 절개도의 재질에 따라 2.8 mm metal, 2.8mm diamond, 3.2 mm diamond blade의 3군으로 환자를 분류한 후 각막 절개창의 변화를 술 후 1일, 1주, 1개월째에 푸리에도메인 방식 빛간섭단층촬영장치인 RTvue (Optovue Inc, Fremont, CA)를 이용하여 술 후 1일, 1주, 1개월째 각막 절개창의 두께, 절단면 각도, 각막 외피 및 내피의 접합, 데스메막 박리 등을 평가하였고, 동시에 시력 및 각막곡률을 측정하여 수술로 인해 유도된 난시 정도를 비교하였다.

결과: 술 후 절개 중앙부의 각막두께는 차이가 없었으나, 측면부의 경우 술 후 모든 경과 관찰기간에서 diamond 2.8mm 군이 다른 두 군보다 유의하게 각막두께가 두꺼웠다. 절단면 각도 상 1개월째 세 군 모두 유의한 차이가 없었으나, 술 후 1일, 1주일에는 diamond

3.2㎜군에서 유의하게 더 절단면의 각도가 가파른 것으로 나타났다. 각막 외피 비접합의 경우 세 군 모두 차이가 없었으나, 각막내피의 비접합, 데스메막 박리, endothelial bullae는 diamond 2.8㎜군이 술 후 한 달까지 다른 두 군보다 유의하게 많았다. 술 후 1달 째 유발된 각막난시는 diamond 3.2㎜ 군이 통계적으로 유의하게 다른 두 군보다 각막난시의 유발이 많았다.

결론: 백내장 수술 시 보다 작은 크기의 diamond 재질, 즉 2.8㎜의 diamond 각막절개도가 다른 두 절개도를 이용한 절개창에 비해 각막부종을 많이 유발하였고, 절개창의 형태학적인 안정성에서도 유의한 저하를 보였다. 각막절개창의 크기가 클수록 각막난시의 유발 정도가 컸지만, 각막절개도의 재질에 따른 각막난시의 유발 정도는 차이가 없었다.

핵심되는 말: 금속 절개도, 다이아몬드 절개도, 창상 안정성, 푸리에 도메인 빛간섭단층촬영계, 투명각막절개