

Original Article

Research on the visual quality contrast after WG-QO-LASEK and WG-SBK for the correction of high myopia

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Abstract: Objective: To observe the visual quality contrast after WG-QO-LASEK and WG-SBK for the correction of high myopia. Method: We carried out the retrospective analysis of pre- and post operative clinical data of 40 cases (80 eyes) that have gone through WG-QO-LASEK and WG-SBK in the department of ophthalmology in our hospital. All patients were required to take preoperative and postoperative examinations including UCVA, BCVA, posterior corneal surface height, WaveScan aberrometer test and so on. And they filled in the NEI RQL-42 table. Results: There was no presence of severe postoperative complications. Each period, there was no significant difference in two groups of patients with uncorrected visual acuity, higher order aberrations. The total high order aberration, spherical aberration and coma were higher in WG-QO-LASEK group than those in WG-SBK group on first month and third months ($P < 0.05$). two groups had no significant difference between the high order aberration, refractive error of quality of life scale NEI RQL-42 after operation between two groups were increased significantly. And the two groups of postoperative subjective visual quality indices were no significant differences. Conclusions: WG-QO-LASEK and WG-SBK in the treatment of myopia have effective prediction, accuracy and safety. On the early days after treatment, the total high order aberration, spherical aberration and coma in WG-QO-LASEK group were higher than WG-SBK group, but after six months, there was no significant difference between the two groups.

Keywords: Wavefront-aberration, LASEK, SBK, higher-order aberrations, NEI RQL-42

Introduction

In 1988 Marguerite McDonald conducted the first Photorefractive Keratectomy (PRK) [1]. Since then, the excimer laser surgery has been ever growing. Currently, the mainstream excimer laser surgery falls into two categories: lamellar cut preserving bowman layer and surface ablation that does not preserve the bowman layer [2]. An increasing number of researches reveal problems brought by the lamellar cut preserving bowman layer, including keratoconus etc [3]. Meanwhile, excimer laser ablation diverts from corneal deep cut to surface ablation [4]. This study observes, compares, and analyzes postoperative visual acuity and visual quality contrast after WG-QO-LASEK and WG-SBK for the correction of high myopia.

Subject and method

Subject

This study adhered to the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board of Fujian provincial-level authorities Hospital, Fuzhou, Fujian Province, China. Informed consent was obtained from all patients after receipt of a detailed description of the study. Retrospective analysis was made about clinical data of 80 cases (160 eyes) of high myopia in the department of ophthalmology from 01. 2014 to 12. 2014. Among all these patients receiving excimer laser surgery, there were 44 males and 36 females, ageing from 18-38 (average age is 24.05). 70 cases were aged from 18-30, 10 cases ageing

from 31-42; UCVA ranged from 0.01 to 0.2, average preoperative visual acuity was 0.035, spherical equivalent refraction was -6.00--13.00 (-6.75±2.01) D. The average preoperative intraocular pressure was 13.43±2.58 mmHg. Best corrected visual acuity (BCVA) was 0.8-1.2, and the central corneal thickness was 468-622 (average 527.2) µm. All patients were random allocated to WG-QO-LASEK group and WG-SBK group. In WG-QO-LASEK group, there were 21 males and 19 females; while in WG-SBK group, there were male 23 and female 17. There was no significant difference in gender and age between two groups. In WG-QO-LASEK group, average preoperative visual acuity was 0.036, spherical equivalent refraction was -6.00-12.75 (-6.78±2.05D), the average preoperative intraocular pressure was 13.48±2.44 mmHg and the central corneal thickness was 468-617 (average 531.2 µm). While in WG-SBK group, average preoperative visual acuity was 0.034, spherical equivalent refraction was -6.25-13.00 (-6.82±1.97D). The average preoperative intraocular pressure was 13.37±2.64 mmHg and the central corneal thickness was 472-622 (average 527.2 µm). There was no significant difference in gender and age between two groups. Patients of groups have taken preoperative and postoperative (3 months and 6 months thereafter). Custom Vue™ WaveScan wavefront-aberration test and have filled in the NEI RQL-42 table [5]. And we observed preoperative and postoperative indices changes including RMS_H, RMS (coma aberration), and RMS (spherical aberration). Meanwhile, other indices changes, like subjective visual quality, were observed as well. Patients also have stopped wearing glasses 2 weeks before operations. All eyes have gone through regular examinations and were confirmed that no optical organic lesion was spotted.

Method

WG-QO-LASEK group: Patients have been treated with antibiotic eye drops for 3 days before operations, and then we applied Proparacaine Hydrochloride eye drops for topical anesthesia after washing the conjunctiva bag. We chose 8.5 mm ethanol cover ring which was vertically put on the corneal surface with the pupil as center. Soak the cornea in the freshly made 200 mL/L alcohol for about 20 seconds to soften the corneal epithelial flap [6]. It was rinsed with equilibrium liquid afterwards;

next, spatula was used to detach the corneal epithelium from its six o'clock direction, so that the corneal stroma was exposed. In the surgery, the analysis system of the aberration instrument was combined with the treatment system of the excimer laser treatment instrument pointing to the pupil center. And the excimer laser ablation was carried out under the flap according to the differences of each eye, and finally reset the flap. After the surgery, filters soaked with 0.02% MMC were applied to the ablating area for 20 s which was then fully washed with compound ringer lactate solution [7]. Eventually, the corneal thin flap was covered and low degree contact lens was worn. Antiphlogistic and hormonal eye drops were used after the surgery. Attention should be paid to the hygienic use of eyes, and regular reexamination was required.

WG-SBK group: Patients have been treated with antibiotic eye drops for 3 days before operations, and then we applied Proparacaine Hydrochloride eye drops for topical anesthesia after washing the conjunctiva bag. Corneal suction rings with different diameters were put in the pupil center according to varied corneal curvatures. We made epithelial flap with Moria One Use-Plus SBK (one-use micro corneal shaper system). SBK epithelial flap was located beside the nose [8]. Reveal the epithelial flap to carry out the laser ablation. Laser ablation was applied on the stromal layer according to data documents collected preoperatively from the aberration system, was then fully washed with compound ringer lactate solution. When completed, reset the flap.

Routine re-examinations have been gone through 1 day, 1 week, 1 month, 3 months, 6 months, and 12 months after operations. Examinations of optometry, wavefront-guided and subjective visual quality were taken 6 months and 12 months after operations respectively. Conditions of UCVA, diopter, intraocular pressure were recorded respectively. In addition, we dealt with postoperative complications and guided the correct medical implementation on patients.

Statistic analysis

SPSS17.0 were used to carry out t-text and variance analysis on data; all data were in the presence of mean Number ± Standard Deviation ($\bar{x} \pm s$), and when $P < 0.05$, differences were statistically significant.

Table 1. UCVA 12 mo after surgeries

Group	≥0.5	≥1.0	≥1.2
WG-QO-LASEK	80 (100)	58 eyes (72.5)	32 eyes (40.0)
WG-SBK	80 (100)	62 eyes (77.5)	38 eyes (47.5)
Chi square test (X ²)	/	P=0.465	P=0.339

Results

Postoperative uncorrected visual acuity (UCVA)

WG-QO-LASEK group: Among 40 cases (80 eyes), 1 week after treatment UCVA of 26 eyes obtained 1.0 or more; 1 month after operations 32 eyes obtained 1.0 or more; 3 months after operations 44 cases obtained 1.0 or more; 6 months after operations 54 eyes obtained 1.0 or more; 12 months after operations 58 eyes obtained 1.0 or more. BCVA of 15 eyes (18.8%) was improved 1 line; BCVA of 8 eyes (10.0%) was improved 2 lines.

WG-SBK group: Among 40 cases (80 eyes), 1 week after operations UCVA of 52 eyes obtained 1.0 or more; 1 month after operations 56 eyes obtained 1.0 or more; 3-6 months after operations 58 eyes obtained 1.0 or more; 12 months after operations 62 eyes obtained 1.0 or more. BCVA of 20 eyes (25.0%) was improved 1 line; BCVA of 10 eyes (12.5%) was improved 2 lines (**Table 1**).

Comparing postoperative visual acuity, the Chi square test showed that early days after surgeries, the recovery of eye acuity in WG-QO-LASEK group is slower than that in WG-SBK group. On the point of 1 week, 1 month and 3 month, the comparative discrepancies have the statistical significance ($P < 0.05$). Meanwhile, on the point of 6 months and 12 months, the comparative discrepancies do not have the statistical significance ($P > 0.05$).

Postoperative epithelial healing and Haze

WG-QO-LASEK group: Postoperatively early stages obvious irritation signs were observed. Patients claimed eyelid-opening apraxia, lacrimation, photophobia and foreign body sensation. 2 days after surgeries the majority of patients felt that FBS was relieved and no obvious eyelid-opening apraxia; the duration of epithelial healing was commonly 3-5 days, with the longest one postoperatively 8 days. Occurrence rate of postoperative Haze was

40%, (according to Fants leveling criteria) 1 month after operations 6 cases of Grade I Haze were observed (12 eyes); Grade 0.5 Haze 12 cases (24 eyes). 6 months after operations 4 cases of Grade I Haze were observed (8 eyes); Grade 0.5 6 cases (12 eyes). 12 months after operations 2 cases of Grade I Haze were observed (4 eyes); Grade 0.5 6 cases (12 eyes).

WG-SBK group: No obvious irritation signs were observed after operations. And 1 day after operations most patients felt that FBS was relieved and no obvious eyelid-opening apraxia. Besides, the duration of epithelial healing was commonly 1-2 days, with the longest one postoperatively 3 days. No postoperative Haze claimed. Although epithelial in growth, reductus on flaps and mild interlayer keratitis were claimed in 3 eyes, corneas remained transparent after the treatment.

Postoperative computer optometry

WG-QO-LASEK group: 1 month after operations, Computer Optometry was $0.09 \pm 0.57D$; 6 months after operations, Computer Optometry was $0.06 \pm 0.54D$; 12 months after operations, Computer Optometry was $0.11 \pm 0.52D$. Diopter comparisons of each pre- and postoperative time-point were statistically significant ($P < 0.05$), but the differences at various postoperative points were not ($P < 0.05$).

WG-SBK group: 1 month after operations, Computer Optometry was $-0.07 \pm 0.69D$; 6 months after operations, Computer Optometry was $-0.01 \pm 0.53D$; 12 months after operations, Computer Optometry was $0.05 \pm 0.59D$; Diopter comparisons of each pre- and postoperative time-point were statistically significant ($P < 0.05$), but the differences at various postoperative points were not ($P < 0.05$).

Discrepancies of diopter comparisons in two sets of data at each time-point did not have the statistical significance ($P < 0.05$).

Wavefront-aberration change

There was no noticeable difference in total high order aberration, spherical aberration and coma aberration for WG-QO-LASEK group and WG-SBK group ($P > 0.05$). In two groups, postoperative total high order aberrations were increased, and had the significance ($P < 0.05$).

Visual quality contrast after WG-QO-LASEK and WG-SBK

Table 2. High order aberration, spherical aberration & coma aberration change

Group	High order aberration change		Spherical aberration change		Coma aberration change	
	WG-QO-LASEK (n=80)	WG-SBK (n=80)	WG-QO-LASEK (n=80)	WG-SBK (n=80)	WG-QO-LASEK (n=80)	WG-SBK (n=80)
pre-	0.361±0.114	0.366±0.117	0.184±0.099	0.182±0.095	0.197±0.099	0.199±0.093
post 1 mo	0.867±0.124 ^A	0.742±0.171 ^{A,B}	0.346±0.111 ^A	0.330±0.110 ^A	0.385±0.088 ^A	0.362±0.101 ^A
post 3 mo	0.810±0.211 ^A	0.714±0.178 ^{A,B}	0.327±0.109 ^A	0.320±0.107 ^A	0.383±0.089 ^A	0.371±0.100 ^A
post 6 mo	0.641±0.212 ^A	0.614±0.189 ^A	0.332±0.109 ^A	0.319±0.111 ^A	0.366±0.083 ^A	0.350±0.100 ^A

^Apresenting at different time-points in the same group $P<0.05$, ^Bpresenting at the same time-point between two different operation groups $P<0.05$.

Table 3. NEI RQL-42 questionnaire

	Pre-		post 1 mo		post 6 mo	
	WG-LASEK (n=80)	WG-SBK (n=80)	WG-LASEK (n=80)	WG-SBK (n=80)	WG-LASEK (n=80)	WG-SBK (n=80)
Visual clarity	63.32±24.60	60.80±15.30	72.58±13.43 ^A	74.29±14.13 ^A	75.58±11.59 ^A	74.58±10.81 ^A
Expectation	37.44±20.72	36.50±21.06	81.54±28.70 ^A	85.65±17.19 ^A	82.07±21.44 ^A	84.22±19.70 ^A
Near vision acuity	78.05±18.25	77.04±19.27	77.23±25.04	74.07±23.09	75.78±21.59	74.28±20.81
Distant vision	65.42±13.70	64.33±15.03	78.68±10.28 ^A	77.59±10.53 ^A	76.58±10.69 ^A	77.38±11.01 ^A
Daytime vision	73.24±13.15	74.29±13.68	74.56±12.87	75.28±13.06	73.86±13.27	73.78±13.27
Limit. of activity	53.44±24.63	52.74±23.78	71.43±22.90 ^A	72.78±21.86 ^A	72.77±21.80 ^A	74.58±20.76 ^A
Glare	75.33±14.11	76.53±16.21	56.71±17.07 ^A	62.51±14.27 ^{A,B}	67.71±17.07 ^A	70.51±13.47 ^{A,B}
Symptom	74.38±12.23	75.22±11.46	77.38±18.23 ^A	82.29±14.55 ^{A,B}	75.22±14.23 ^A	84.22±13.74 ^{A,B}
Dependence on CVA	32.49±21.95	33.78±20.48	75.68±11.48 ^A	76.39±10.63 ^A	76.57±11.28 ^A	76.69±10.93 ^A
Worry	49.76±22.52	50.26±21.35	68.45±13.71 ^A	70.86±13.57 ^A	71.54±12.70 ^A	71.65±13.19 ^A
Poor VA	69.69±12.82	70.59±13.27	94.01±10.63 ^A	94.54±11.37 ^A	93.28±10.42 ^A	95.02±10.87 ^A
Appearance	51.33±30.06	53.23±31.52	86.35±12.63 ^A	88.38±11.80 ^A	84.59±12.53 ^A	85.58±12.69 ^A
Satisfaction	58.48±20.11	56.02±21.47	74.68±12.28 ^A	76.59±12.53 ^A	75.58±11.69 ^A	77.98±13.01 ^A
Total	63.22±26.15	63.58±25.87	76.15±13.83 ^A	78.68±14.28 ^A	77.53±13.69 ^A	77.68±14.01 ^A

^Apresenting at different time-points in the same group $P<0.05$, ^Bpresenting at the same time-point between two different operation groups $P<0.05$.

Postoperatively, in the first month and the third month, total high order aberrations in WG-QO-LASEK group was higher than those in SBK group, and the differences were significant ($P<0.05$). 6 months after operations, higher order aberrations in two groups were decreased compared with those in 1 month after operations and the difference had statistical significance ($P<0.05$). But the intra-group comparison had no statistical significance. Within the WG-QO-LASEK group, comparisons between pre-operations and postoperative 1 month, 3 months and 6 months had statistical significance ($P<0.05$). By making comparisons between each time period of postoperative 1 month, 3 month and 6 month, it can be found that higher order aberrations decreased as the time went by, and the difference had statistical significance ($P<0.05$). Within the WG-SBK

group, comparisons between pre-operations and postoperative 1 month, 3 months and 6 months had statistical significance as well ($P<0.05$). By making comparisons between each time period of postoperative 1 month, 3 month and 6 month, it can also be found that higher order aberrations decreased as the time went by, and the difference had statistical significance as well ($P<0.05$). After operations in the third and the sixth month, both coma aberration and Spherical aberration were increased. Comparisons between the WG-QO-LASEK group and the WG-SBK group had no statistical significance ($P>0.05$) (Table 2).

Subjective visual quality and NEI RQL-42

Both WG-QO-LASEK group and WG-SBK group filled up NEI RQL-42 preoperatively and 1 month

and 6 months after operations. As patients have filled up the questionnaires, the table's validity and reliability should be analyzed. For the pre- and postoperative data from groups of patients, *Cronbach a*>0.7; while intraclass correlation coefficient of the test-retest reliability was 0.81-0.85. Evaluated by the t-test of sample means, for WG-QO-LASEK group the preoperative visual quality scored 63.22 ± 26.15 and WG-SBK group visual quality scored 63.58 ± 25.87 , and after WG-QO-LASEK, the visual quality scored 77.53 ± 13.69 , WG-SBK group visual quality scored 77.68 ± 14.01 , which showed no statistical significance ($P > 0.05$). In terms of these 10 indices including subjective visual clarity, expectation, distant vision, limitation of activity, symptoms, the dependence on the corrected visual acuity, worry, poor visual acuity, appearance, satisfaction, postoperative scores of two groups were increased, and the difference had the statistical significance ($P < 0.05$). The postoperative scores of glare were decreased, and the difference had the statistical significance ($P < 0.05$). In terms of other two indices, namely near vision acuity and the daytime visual fluctuation, there was no statistical significance ($P > 0.05$) (See **Table 3**).

Discussions

The surface refractive surgery make a new way for patients with rather thin cornea to save the thickness of their corneas [9]. WG-QO-LASEK and WG-SBK have gained increasing attention from the public. Therefore, this paper mainly studies the effects of WG-QO-LASEK and WG-SBK on the visual quality of patients with high myopia.

Features of WG-QO-LASEK and WG-SBK

(1) Common features: they both use wavefront-guided system to reduce the postoperative aberration and to improve visual quality. In the surgery, preoperative examination results from the aberration instrument analyzing system are combined with the treatment system of the excimer laser treatment system. The eyeball dynamic tracking system emits infrared rays. Through the video tracking, the offset amount of the eyeball can be accurately calculated in the operation, by which the de-central ablation caused by the eyeball rotation is avoided and the deviation value is reduced. Due to the

decrease of the eyeball offset, the occurrence of the postoperative higher order aberration, especially the coma aberration, is diminished [10]; (2) Dissimilarities: what WG-QO-LASEK make is the epithelial flap that is only 50~60 μm thick [11], which is the thinnest in the current laser surgery. While for the WG-SBK, it uses Moria microkeratome M2 110 to prepare the flap with the average thickness 161.1 μm [12]. Although this figure is larger than that of WG-QO-LASEK, it is still relatively quite thin among these laser surgeries [13]; (3) Postoperative Haze of LASEK still influences the early improvement of the visual acuity [14]. WG-QO-LASEK, as an improvement of LASEK, is not free from such problem. After the WG-QO-LASEK, we apply filters soaked with 0.02% MMC to the ablating area for 10-25 s [15]. The depth of the laser cutting is estimated according to the myopia degree, and the covering time of postoperative MMC filters range from 10 s to 25 s, so that the occurrence of Haze is diminished and the postoperative BCVA and visual quality are thus improved [16].

Analysis of the postoperative effect

There is no presence of severe postoperative complications in patients of both groups. NEI RQL-42 total scores are increased compared to preoperative scores. Meanwhile, ten indices including subjective visual clarity, distant vision, limitation of activity, symptoms, dependence on the corrected visual acuity, worry, poor visual acuity, appearance and satisfaction show no discrepancy between two groups. However, in WG-QO-LASEK group, obvious irritation signs are observed in early days after operations, most patients felt that 2 days later FBS is relieved. On the contrary, no obvious irritation signs are observed after operations in WG-SBK group, which can also be traced in the item of symptom in NEI RQL-42 where WG-QO-LASEK group scores lower than WG-SBK group, and the difference has the statistical significance ($P < 0.05$). In terms of the postoperative UCVA, early stages after the operations, visual acuity in WG-QO-LASEK group recovers slower than that in WG-SBK, and the comparisons of 1 wk, 1 mo and 3 mo have the statistical significance. But as the time goes by, VA of two groups become unified, therefore postoperatively, the comparisons in the 6th month and the 12th month do not have the statistical significance. The differences between two groups of visual

acuties are mainly caused by the postoperative formation of early Haze in WG-QO-LASEK surgery, which influences the visual acuity improvement. Past researches have shown that in PRK, the occurrence rate of postoperative early Haze is as high as 92-100% and higher than 50% even half of the year later [17]. In LASEK surgery, although the activity of the epithelial flap functions to reduce the formation of the Haze, for -8.00D or higher, the occurrence rate of Haze increases remarkably [18]. Therefore, the visual acuity recovers slower after such surgeries than in WG-SBK group. Frings A [19] etc. attempted to use 0.02% Mitomycin in LASEK on moderate and high myopia patients, which efficiently prevented the postoperative Haze from happening. In this study, according to the depth of the laser cutting and the myopia degree, the ablating area is covered by filters soaked with 0.02% MMC after the laser surgery, and then washed by aseptic water. MMC filters covering the ablation area only have effect on stoma keratocyte of the ablating area, avoiding the surrounding histocytes and effectively reducing the occurrence rate of the operative Haze, thus the postoperative VA is improved. Due to this, around half of the year later, visual acuities of two groups become unified. Currently, what has been generally agreed is that diopter surgery increases the higher order aberration [20, 21]. Postoperative total high order aberrations in both WG-QO-LASEK group and WG-SBK group increase compared to those before operations, and in terms of "glare" in NEI RQL-42 table, they score lower than before as well. Despite the fact that two groups apply surface ablation, postoperative increase of the higher order aberration is inevitable. Postoperatively in 1st month and 3rd month, Haze caused by operations not only exerts inescapable effect on the presence of the postoperative early higher order aberration [22], but also lead to the fact that total high order aberrations in WG-QO-LASEK group are higher than those in the WG-SBK group. However, factors including changes of asphericity of corneal anterior surfaces, de-central ablation, pupil factor and dioptric system all exert the same effect on WG-QO-LASEK operation and WG-SBK operation, and they are even main factors [23]. As the postoperative Haze in WG-QO-LASEK group decreases, its influence on higher order aberration lessens, hence, in the 6th month after operations, indices of total high order aberration,

spherical aberration and coma aberration in two groups become unified. Currently, reasons why after excimer laser surgery eye higher order aberrations noticeably increase are as follows:

(1) The laser surgery is unable to eliminate completely the higher order aberration of patients himself [24]. Most patients themselves have higher order aberrations that only occupy a so small proportion that they are unable to exert some effect on the visual quality. In addition, the refractive surgery eliminates patients' lower order aberration, making the higher order aberration the main aberration. Especially for patients with high myopia, higher order aberrations would be inhibited by lower order aberrations. Once the lower order aberrations are eliminated, the higher order aberrations become the main factor influencing the visual quality; (2) Pupil size: there exists a relation among corneal wave aberrations, corneal topography and pupil offset [25]. What's more, the corneal aspheric coefficient has the most powerful influence on higher order aberrations; (3) Higher order aberrations are introduced during the operative process. The preparation of the epithelial flap, laser ablation and resetting the cornea could introduce higher order aberration [26]; (4) Higher order aberrations are produced during the healing process; (5) The limitation of wavefront-aberration instrument. When carrying out the ablation, data loaded could not be completely transferred to the wavefront data.

To conclude, although WG-QO-LASEK and WG-SBK would increase the operative higher order aberrations, they do not significantly influence patients' visual quality. Therefore, they are safe and effective operations of correcting high Myopia.

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Disclosure of conflicts of interest

None.

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References

- [1] Xu GX. Laser in Ophthalmology. BJ: Higher Education Press; 2011 pp. 6-10.
- [2] Lee K, Ahn JM, Kim EK, Kim TI. Comparison of optical quality parameters and ocular aberrations after wavefront-guided laser in-situ keratomileusis versus wavefront-guided laser epithelial keratomileusis for myopia. *Graefes Arch Clin Exp Ophthalmol* 2013; 251: 2163-9.
- [3] Yan P, Du Z, Wu N, Zhang Y, Xu Y. Minor influence of sub-bowman keratomileusis on the posterior corneal surface at early stage. *Curr Eye Res* 2013; 38: 871-9.
- [4] McAlinden C, Moore JE. Comparison of higher order aberrations after LASIK and LASEK for myopia. *Refract Surg* 2010; 26: 45-51.
- [5] Nehls SM, Ghoghawala SY, Hwang FS, Azari AA. Patient satisfaction and clinical outcomes with laser refractive surgery performed by surgeons in training. *J Cataract Refract Surg* 2014; 40: 1131-8.
- [6] Grewal DS, Brar GS, Grewal SP. Posterior corneal elevation after LASIK with three flap techniques as measured by Pentacam. *J Refract Surg* 2011; 27: 261-8.
- [7] de Benito-Llopis L, Teus MA. Efficacy of surface ablation retreatments using mitomycin C. *Am J Ophthalmol* 2010; 150: 376-380.
- [8] Zhang J, Zhang SS, Yu Q, Wu JX, Lian JC. Comparison of corneal flap thickness using a FS200 femtosecond laser and a moria SBK microkeratome. *Int J Ophthalmol* 2014; 7: 273-7.
- [9] Kulkarni SV, AlMahmoud T, Priest D, Taylor SE, Mintsoulis G, Jackson WB. Long-term visual and refractive outcomes following surface ablation techniques in a large population for myopia correction. *Invest Ophthalmol Vis Sci* 2013; 54: 609-19.
- [10] Ahn HS, Chung JL, Kim EK, Seo KY, Kim TI. Changes in spherical aberration after various corneal surface ablation techniques. *Korean J Ophthalmol* 2013; 27: 81-6.
- [11] Djodeyre MR, Ortega-Usobiaga J, Beltran J, Baviera J. Long-term comparison of laser in situ keratomileusis versus laser surface ablation in corneas thinner than 470 μ m. *J Cataract Refract Surg* 2012; 38: 1034-42.
- [12] Lian JC, Zhang SS, Zhang J, Ye S. Comparison of cornea flap made by femtosecond laser and microkeratome in laser in situ keratomileusis. *Zhonghua Yan Ke Za Zhi* 2013; 49: 305-8.
- [13] Ahn JM, Choi BJ, Kim EK, Sgrignoli B, Kim TI. Three different aspheric treatment algorithms of laser-assisted sub-epithelial keratectomy in patients with high myopia. *Jpn J Ophthalmol* 2013; 57: 191-8.
- [14] Hansen RS, Lyhne N, Grauslund J, Grønbech KT, Vestergaard AH. Four-year to seven-year outcomes of advanced surface ablation with excimer laser for high myopia. *Graefes Arch Clin Exp Ophthalmol* 2015; 253: 1027-33.
- [15] Huisinigh C, McGwin G Jr. Keratocyte density 3 months, 15 months, and 3 years after corneal surface ablation with mitomycin C. *Am J Ophthalmol* 2012; 153: 1007.
- [16] Reilly CD, Panday V, Lazos V, Mittelstaedt BR. PRK vs LASEK vs Epi-LASIK: a comparison of corneal haze, postoperative pain and visual recovery in moderate to high myopia. *Nepal J Ophthalmol* 2010; 2: 97-104.
- [17] Korkmaz S, Bilgihan K, Sul S, Hondur A. A Clinical and Confocal Microscopic Comparison of Transepithelial PRK and LASEK for Myopia. *J Ophthalmol* 2014; 2014: 784185.
- [18] Zhao LQ, Zhu H, Li LM. Laser-Assisted Subepithelial Keratectomy versus Laser In Situ Keratomileusis in Myopia: A Systematic Review and Meta-Analysis. *ISRN Ophthalmol* 2014; 2014: 672146.
- [19] Frings A, Vidic B, El-Shabrawi Y, Arjomand N. Laser-assisted subepithelial keratomileusis with mitomycin C for myopic astigmatism ≥ 2.00 diopters using a Zeiss MEL 80 Excimer. *Int Ophthalmol* 2014; 34: 225-33.
- [20] Yvon C, Archer TJ, Gobbe M, Reinsteinst DZ. Comparison of higher-order aberration induction between manual microkeratome and femtosecond laser flap creation. *J Refract Surg* 2015; 31: 130-5.
- [21] AlArfaj K, Hantera MM. Comparison of LASEK, mechanical microkeratome LASIK and Femtosecond LASIK in low and moderate myopia. *Saudi J Ophthalmol* 2014; 28: 214-9.
- [22] Qian Y, Huang J, Chu R, Zhou X, Olszewski E. Influence of intraocular astigmatism on the correction of myopic astigmatism by laser-assisted subepithelial keratectomy. *J Cataract Refract Surg* 2014; 40: 558-63.
- [23] Huang H, Yang J, Bao H, Chen S, Xia B, Zou J. Retrospective analysis of changes in the anterior corneal surface after Q value guided LASIK and LASEK in high myopic astigmatism for 3 years. *BMC Ophthalmol* 2012; 12: 15.
- [24] Jung JW, Chung BH, Han SH, Kim EK, Seo KY, Kim TI. Comparison of Measurements and Clinical Outcomes After Wavefront-Guided LASEK Between iDesign and WaveScan. *J Refract Surg* 2015; 31: 398-405.
- [25] Arora R, Goel Y, Goyal JL, Goyal G, Garg A, Jain P. Refractive outcome of wavefront guided laser in situ keratomileusis and wavefront guided photorefractive keratectomy in high pre-existing higher order aberration. *Cont Lens Anterior Eye* 2015; 38: 127-33.
- [26] Yu CQ, Manche EE. Day 1 wavefront aberrometry for prediction of refractive outcomes at year 1 in myopic LASIK. *J Refract Surg* 2015; 31: 170-4.