

# Consistent comparison of angle Kappa adjustment between Oculyzer and Topolyzer Vario topography guided LASIK for myopia by EX500 excimer laser

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## Abstract

• **AIM:** To evaluate and compare the uniformity of angle Kappa adjustment between Oculyzer and Topolyzer Vario topography guided ablation of laser *in situ* keratomileusis (LASIK) by EX500 excimer laser for myopia.

• **METHODS:** Totally 145 cases (290 consecutive eyes) with myopia received LASIK with a target of emmetropia. The ablation for 86 cases (172 eyes) was guided manually based on Oculyzer topography (study group), while the ablation for 59 cases (118 eyes) was guided automatically by Topolyzer Vario topography (control group). Measurement of adjustment values included data respectively in horizontal and vertical direction of cornea.

• **RESULTS:** Horizontally, synclastic adjustment between manually actual values ( $dx_{\text{manu}}$ ) and Oculyzer topography guided data ( $dx_{\text{ocu}}$ ) accounts 35.5% in study group, with mean  $dx_{\text{manu}}/dx_{\text{ocu}}$  of  $0.78\pm 0.48$ ; while in control group, synclastic adjustment between automatically actual values ( $dx_{\text{auto}}$ ) and Oculyzer topography data ( $dx_{\text{ocu}}$ ) accounts 54.2%, with mean  $dx_{\text{auto}}/dx_{\text{ocu}}$  of  $0.79\pm 0.66$ . Vertically, synclastic adjustment between  $dy_{\text{manu}}$  and  $dy_{\text{ocu}}$  accounts 55.2% in study group, with mean  $dy_{\text{manu}}/dy_{\text{ocu}}$  of  $0.61\pm 0.42$ ; while in control group, synclastic adjustment between  $dy_{\text{auto}}$  and  $dy_{\text{ocu}}$  accounts 66.1%, with mean  $dy_{\text{auto}}/dy_{\text{ocu}}$  of  $0.66\pm 0.65$ . There was no statistically significant difference in ratio of actual values/Oculyzer topography guided data in horizontal and vertical direction between two groups ( $P=0.951, 0.621$ ).

• **CONCLUSION:** There is high consistency in angle Kappa adjustment guided manually by Oculyzer and guided automatically by Topolyzer Vario topography during corneal refractive surgery by WaveLight EX500 excimer laser.

• **KEYWORDS:** angle Kappa; adjustment; Oculyzer; Topolyzer; uniformity; laser *in situ* keratomileusis

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## INTRODUCTION

Laser *in situ* keratomileusis (LASIK) has been acknowledged as one of the most widely performed corneal refractive surgery for the correction of myopia, for its high rate of safety and predictability, good visual outcomes and minimal postoperative discomfort<sup>[1-3]</sup>. Despite generally satisfactory outcomes of LASIK, we need to pay more attention to the high precision and better visual outcomes and to improve some surgical parameters such as ablation centration and the size of optical zone<sup>[4-11]</sup>.

As one of the factors that may impact corneal aberrations induced by laser refractive surgery, ablation centration has been taken great account of particularly in eyes with large angle Kappa<sup>[12-16]</sup>. The angle Kappa is formally defined as the angular distance in the object space between the pupillary axis and the line of sight<sup>[17]</sup>. It could be identified clinically by the nasal displacement of the corneal light reflex from the pupil center, thus, to some extent, it means the misalignment of light passing through the refractive surface of the cornea and the bundle of light formed by the pupil. Therefore, the measurement of angle Kappa is of great significance and paramount consideration in refractive surgery, in order to get the good postoperative optical outcomes. Many studies have concerned decentered ablation in refractive surgery<sup>[18]</sup> and angle Kappa adjustment according to topography guidance in excimer laser platform. While how to make an appropriate adjustment when it failed to match the image from topography with the live image during surgery by excimer laser platform is still being unclear. Therefore, this study is performed to compare the effect between angle Kappa adjustment manually based on Oculyzer topography and adjustment automatically guided by Topolyzer Vario topography in ablation of LASIK

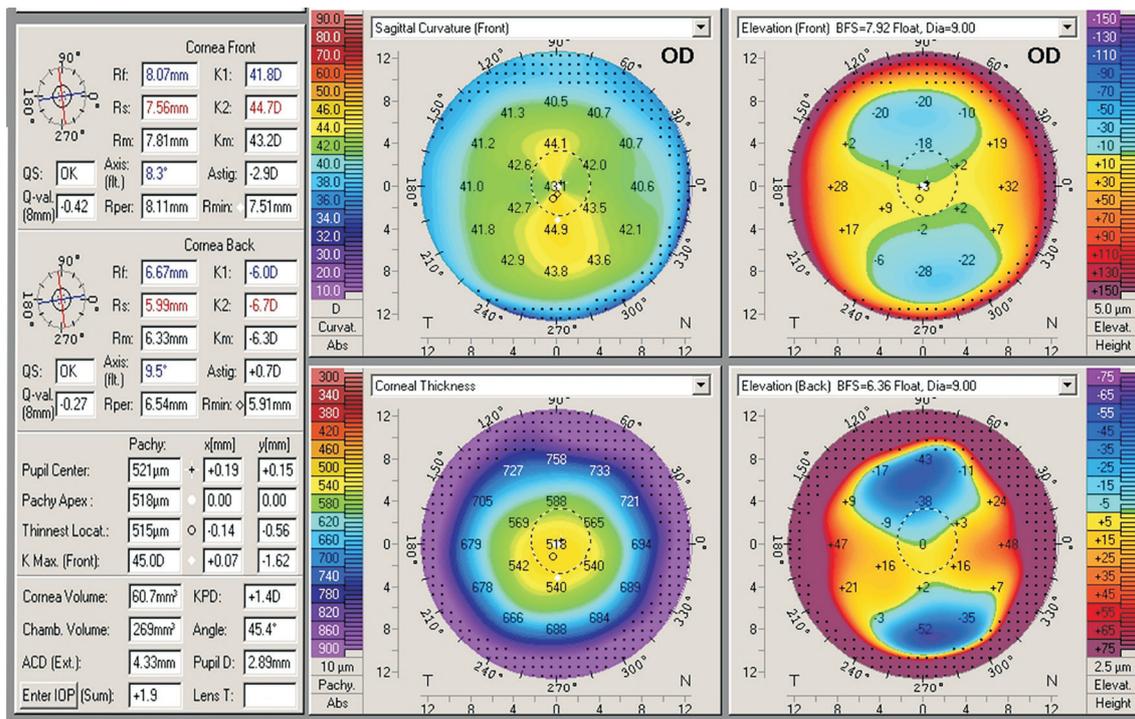


Figure 1 Angle Kappa adjustment guided by Oculyzer topography.

for myopia, in order to evaluate the clinic value of Oculyzer topography guidance in angle Kappa adjustment during LASIK surgery.

### SUBJECTS AND METHODS

This retrospective comparative study comprised 290 eyes of consecutive 145 patients who were performed LASIK from March 2014 to October 2015 in Beijing Tongren Hospital. The study was approved by the Institute's Ethics and Research Committee and fulfilled the principles of the Declaration of Helsinki. Before surgery each patient was informed about the surgery and signed informed consent.

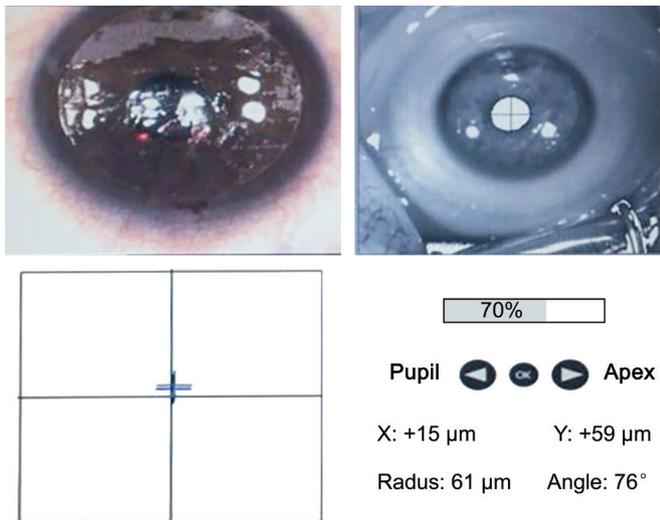
Preoperative examination included logMAR uncorrected distance visual acuity (UDVA) and corrected distance visual acuity (CDVA), manifest refraction and cycloplegic refraction, slit-lamp examination, handy ultrasonic pachymetry (TOMEYSP-100, Japan), corneal topography (Topolyzer Vario; Oculyzer, WaveLight, Germany), and fundus evaluation. The relative positions of pupil centers with respect to corneal apex were registered by means of topographic Cartesian coordinates ( $dx_{ocu}$  and  $dy_{ocu}$  in Oculyzer,  $dx_{topo}$  and  $dy_{topo}$  in Topolyzer Vario).

Inclusion criteria were eyes with preoperative CDVA of 20/20 or better, stable refractive diopter more than 2y before surgery, contact lens wear discontinuation for at least 2wk before surgery. Exclusion criteria included keratoconus, glaucoma, cataract, corneal and retinal diseases, infectious diseases, abnormal topography, expected residual bed thickness after LASIK less than 300 µm, expected total pachymetry after LASIK less than 400 µm, and previous refractive surgery.

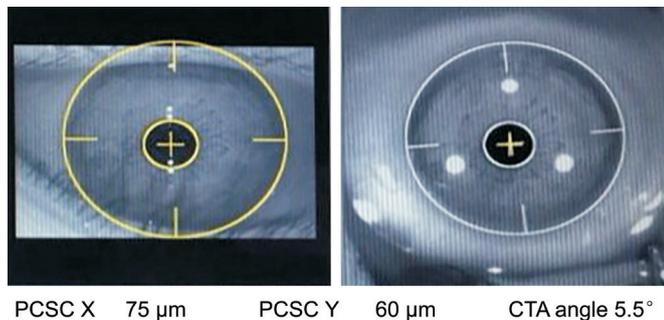
**Surgical Technique** LASIK was performed by using the WaveLight EX500 excimer laser (WaveLight GmbH, Germany). Surgeries for all cases were performed by one experienced surgeon (Zhang FJ). All treatments were based on optimized aspheric ablation profiles. The flaps were created with the One Use-Plus microkeratome (Moria SA, France) with the hinge on the nasal position. Photoablation was applied to at least 6.0-mm optical zone, with a transition zone of 9 mm. After folding the corneal flap, the laser beam was focused according to the group of the eye. For the study group, the laser beam was manually centered based on the comparison of corneal topography obtained from Oculyzer (Figure 1) and the live image taken from the WaveLight EX500 platform, and the Cartesian coordinates ( $dx_{manu}$  and  $dy_{manu}$ ) of the ablation were recorded, whereas for the control group, the laser beam was centered automatically guided by the Topolyzer Vario topography image matched with live image in WaveLight EX500 platform, with the Cartesian coordinates ( $dx_{auto}$  and  $dy_{auto}$ ) of the ablation recorded (Figures 2, 3). Once the laser beam was centered, the active eye tracker system was turned on, and the ablation was performed. After the ablation, the flap was then carefully repositioned over the treatment area by the surgeon and checked for the dislocation of flap, debris and bleeding. The flap remains in position by natural adhesion until healing is completed.

Levofloxacin eye drops 0.5% (Santen, Japan), fluorometholone eye drops 0.1% (Allergan, Ireland), and sodium hyaluronate eye drops 0.1% (URSAPHARM Arzneimittel GmbH, Germany) were used four times a day in two weeks postoperatively. Patients were followed up at 1d, 1wk and 1mo after the surgery.

## Uniformity of Kappa adjustment in two topography



**Figure 2** Manually adjustment based on Oculyzer topography in study group  $dx_{manu}/dx_{ocu}$  and  $dy_{manu}/dy_{ocu}$  mean the ratio of manually actual values in Figure 2 to Oculyzer topography guided data in Figure 1 in synclastic group.



**Figure 3** Automatically adjustment guided by Topolyzer Vario topography in control group  $dx_{auto}/dx_{ocu}$  and  $dy_{auto}/dy_{ocu}$  mean the ratio of automatically actual values in Figure 3 to Oculyzer topography guided data in Figure 1 in synclastic group.

**Statistical Analysis** Statistical analysis was performed with the SPSS for Windows, version 20.0 (IBM-SPSS, Chicago, Illinois, USA). Visual acuity was converted to logMAR equivalent. The continuous variable were expressed as mean±standard deviation. Independent *t*-test or Mann-Whitney *U* test for continuous variables, as appropriate, after testing for normal distributions. The categorical data were expressed as percentage. A *P* value of less than 0.05 was considered statistically significant. The correlation between different variables was assessed with the correlation coefficients.

Each Cartesian coordinate was analyzed separately in *dx* and *dy*. In each direction, we divided data of actual adjustment and Oculyzer topography-guided adjustment into 4 groups: synclastic adjusted (actual adjustment and Oculyzer topography-guided adjustment in the same direction); opposite adjusted (actual adjustment and Oculyzer topography-guided adjustment in the opposite direction); unadjusted (without adjustment actually) and adjusted with no guidance (actual adjustment without Oculyzer topography guidance).

**Table 1** Comparison of visual and refractive outcomes between two groups preoperatively

Preoperative parameters	mean±SD		
	Study group ( <i>n</i> =172)	Control group ( <i>n</i> =118)	<i>P</i>
Age	24.80±6.43	24.20±6.23	0.404
UDVA (logMAR)	1.08±0.28	1.01±0.40	0.092
CDVA (logMAR)	-0.06±0.04	-0.06±0.05	0.687
Sphere (D)	-4.67±1.63	-4.73±1.54	0.721
Cylinder (D)	-0.67±0.54	-0.69±0.53	0.102
SE (D)	-5.00±1.67	-5.08±1.64	0.297

UDVA: Uncorrected distance visual acuity; CDVA: Corrected distance visual acuity; SE: Spherical equivalen.

## RESULTS

The study comprised 290 eyes of 145 patients, 172 eyes of 86 patients in the study group and 118 eyes of 59 patients in the control group. Tables 1 and 2 demonstrated that there was no statistically significant difference between two groups in refraction and visual acuity preoperatively and 1d, 1wk, 1mo postoperatively.

Figures 4 and 5 showed the comparison of percentage of eyes in 4 groups between the study and control groups in horizontal and vertical direction. In the overall analysis, 61 eyes (35.5%) were synclastic adjusted and 73 eyes (42.4%) were unadjusted in horizontal direction in the study group, with 64 eyes (54.2%) were synclastic adjusted and 29 eyes (24.6%) were unadjusted in the control group. In vertical direction, 95 eyes (55.2%) were synclastic adjusted and 50 eyes (29.1%) were unadjusted in the study group, with 78 eyes (66.1%) were synclastic adjusted and 20 eyes (16.9%) were unadjusted in the control group. In both two directions, percentage of synclastic adjusted eyes in the study group were less than that in the control group, while the percentage of unadjusted eyes in the study group were more.

In unadjusted eyes of the study group, overall 61 eyes (83.6%) were within ±100 μm of Oculyzer topography guidance and 70 eyes (95.9%) were within ±140 μm in horizontal direction, and 46 eyes (92.0%) were within ±100 μm of Oculyzer topography guidance and 49 eyes (98.0%) were within ±140 μm in vertical direction.

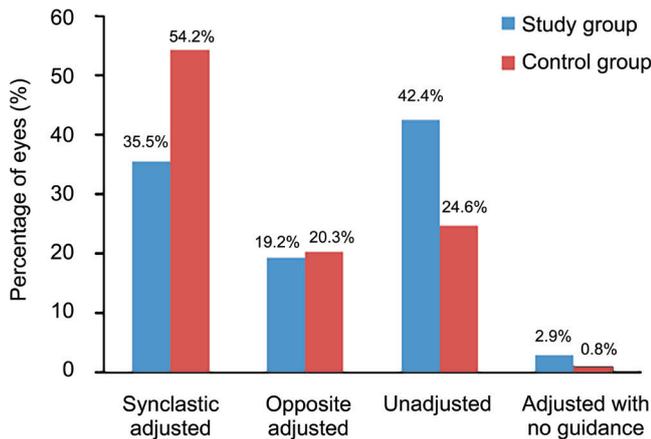
The mean ratio of Cartesian coordinate in synclastic adjusted eyes in the study group ( $dx_{manu}/dx_{ocu}$  of 0.78±0.48,  $dy_{manu}/dy_{ocu}$  of 0.61±0.42) were similar with which in the control group ( $dx_{auto}/dx_{ocu}$  of 0.79±0.66,  $dy_{auto}/dy_{ocu}$  of 0.66±0.65) in both direction. There was no statistically significant difference between two groups (*P*=0.951, 0.621).

Figures 6 and 7 showed two scatterplot of actual values versus Oculyzer topography-guided data in synclastic adjusted group. In horizontal direction, the correlation coefficient of actual values ( $dx_{manu}$ ) and Oculyzer topography-guided data ( $dx_{ocu}$ ) in the study group (*R*=0.871, *P*=0.000) was higher than that in the control group (*R*=0.709, *P*=0.000). While in vertical direction, the correlation coefficient of actual values ( $dy_{manu}$ )

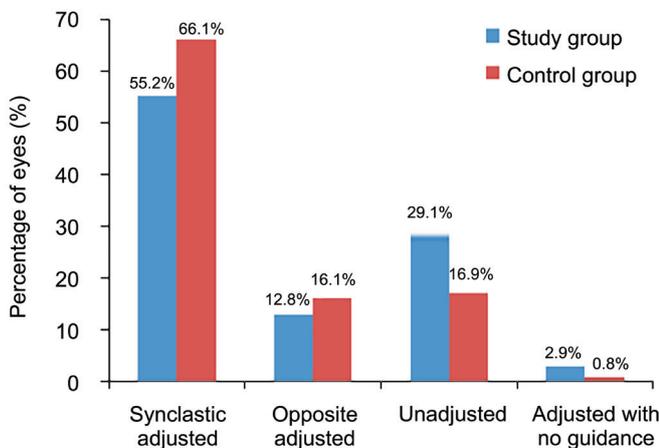
**Table 2 Comparison of visual and refractive outcomes between two groups postoperatively** mean±SD

Postoperative parameters	Postoperative 1d			Postoperative 1wk			Postoperative 1mo		
	Study group (n=172)	Control group (n=118)	P	Study group (n=164)	Control group (n=114)	P	Study group (n=140)	Control group (n=102)	P
UDVA (logMAR)	-0.12±0.05	-0.10±0.07	0.332	-0.14±0.06	-0.12±0.05	0.282	-0.14±0.05	-0.14±0.05	0.674
CDVA (logMAR)	-0.12±0.06	-0.10±0.06	0.380	-0.14±0.06	-0.12±0.05	0.250	-0.14±0.05	-0.14±0.06	0.720
Sphere (D)	0.24±0.33	0.22±0.40	0.265	0.23±0.42	0.22±0.42	0.521	0.16±0.36	0.17±0.37	0.443
Cylinder (D)	-0.29±0.31	-0.26±0.26	0.298	-0.29±0.39	-0.27±0.28	0.302	-0.30±0.35	-0.32±0.36	0.387
SE (D)	0.10±0.33	0.09±0.39	0.224	0.09±0.40	0.09±0.41	0.397	0.01±0.35	0.01±0.37	0.421

UDVA: Uncorrected distance visual acuity; CDVA: Corrected distance visual acuity; SE: Spherical equivalent.



**Figure 4 Comparison of percentage of eyes in four groups between the study group and the control group in horizontal direction.**

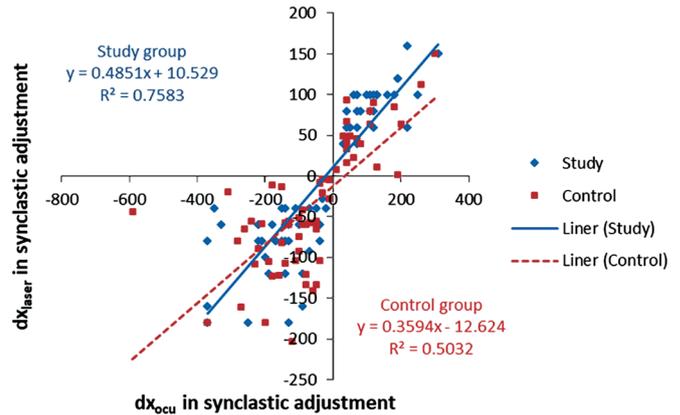


**Figure 5 Comparison of percentage of eyes in four groups between the study group and the control group in vertical direction.**

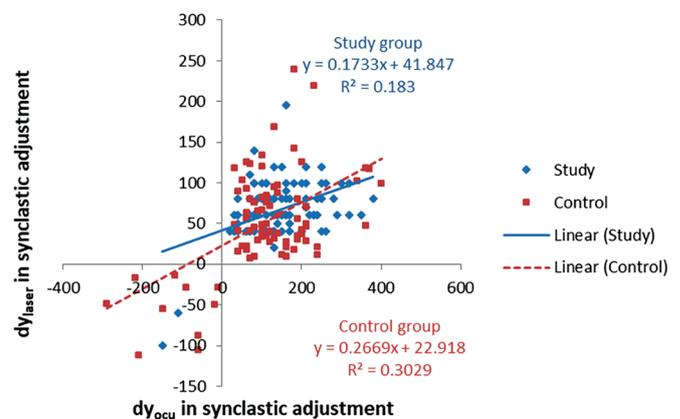
and Oculyzer topography-guided data ( $dy_{ocu}$ ) in the study group ( $R=0.428$ ,  $P=0.000$ ) was lower than which in the control group ( $R=0.549$ ,  $P=0.000$ ).

### DISCUSSION

Research showed that the accuracy of refractive outcomes was highly correlated with the precise alignment of the ablation to the intended location on the cornea<sup>[19]</sup>. In addition, angle Kappa of eye is one of other vital factors causing misalignment in refractive surgery<sup>[20]</sup>. Arbelaez *et al*<sup>[6]</sup> also indicated the importance of measuring decentration values and adjusting them using the laser ablation algorithm.



**Figure 6 Actual values versus Oculyzer topography-guided data in synclastic adjusted group in horizontal direction.**



**Figure 7 Actual values versus Oculyzer topography-guided data in synclastic adjusted group in vertical direction.**

Oculyzer and Topolyzer Vario display X-Y Cartesian coordinates correlation between the corneal vertex and pupil center. When we focus on a target, the cornea vertex as a reproducible point is the highest point, nearing the line of sight and independent of pupil size. If the human optical system were coaxial, the intersection of the optical axis and the cornea is exactly the cornea vertex. The angle between optical and visual axes at the nodal point is termed the angle Alpha, which positively correlating with angle Kappa<sup>[6,12]</sup>.

In this study, we compared the mean ratio of  $dx_{actual}/dx_{ocu}$  and  $dy_{actual}/dy_{ocu}$  respectively in synclastic adjusted eyes in the study and control groups, and found that there was no statistically significant difference between them. In addition, correlation

analysis between actual values and Oculyzer topography-guided data yielded a substantial correlation in both groups in horizontal and vertical direction. And there was not significant difference between the study and control group in correlation coefficient. Meanwhile, the visual and refractive outcomes were similar between two groups in at 1d, 1wk and 1mo postoperatively.

Not all lasers have specific software and/or hardware to automatically adjust for decentration from angle Kappa, and the image obtained from corneal topography may fail to match with the live image during surgery by excimer laser platform occasionally. To make an appropriate adjustment in ablation, analysis of preoperative topography guidance combined with intra-operative condition is of great importance for surgeon. In our clinic, it is evident that the effect of manually angle Kappa adjustment based on Oculyzer topography guidance is similar to automatically angle Kappa adjustment guided by Topolyzer Vario topography with WaveLight EX500 excimer laser. Therefore, such manually adjustment guided by Oculyzer topography is recommended in the condition of mismatch between Topolyzer Vario topography and the live image during surgery. However, pupil center shift compensation and cyclotorsion compensation are also important for the exact results of ablation in the eye with high myopia and high myopic astigmatism<sup>[21-22]</sup>, therefore, the successful rate of diagnostic image match with live image based on Topolyzer Vario guidance should be improved and be recommended in order to achieve more accurate data, especially the angle of cyclotorsion.

The retrospective design and small sample may be viewed as the limitations of this study. Another limitation is that only myopic patients were incorporated in this study, whose decentration values were low and unobvious compared with hyperopic patients. Till now, topography-guided excimer laser ablation (T-CAT) for hyperopia has been commonly used in our clinic with perfect centration ablation to compensate the large angle Kappa for hyperopic eyes. While, prospective studies including T-CAT for hyperopic patients would be investigated further.

In conclusion, this study demonstrated the high consistency in angle Kappa adjustment guided by Oculyzer topography and Topolyzer Vario topography. The data from Oculyzer topography makes significant sense when the image from Topolyzer Vario topography fails to match with the live image during surgery by WaveLight EX500 excimer Laser.

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**Authors' contributions:** Sun MS is responsible for data acquisition, data analysis, drafting manuscript and statistical analysis; Zhang L is responsible for data acquisition; Guo N and Song YZ are responsible for data analysis; Zhang FJ is responsible for the surgical procedure and protocol

design, critical revision of manuscript, securing funding and supervision.

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