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# Digital Pupillometry and Centroid Shift Changes in Dominant and Nondominant Eyes

# Digitale Pupillometrie und Zentroidverschiebungsänderungen in dominanten und nicht dominanten Augen

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Schlüsselwörter

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## ABSTRACT

**Purpose** To investigate the differences between dominant and nondominant eyes in a predominantly young patient population by analyzing the angle kappa, pupil size, and center position in dominant and nondominant eyes.

**Methods** A total of 126 young college students (252 eyes) with myopia who underwent femtosecond laser-combined LASIK were randomly selected. Ocular dominance was determined using the hole-in-card test. The WaveLight Allegro Topolyzer (WaveLight Laser Technologies AG, Erlangen, Germany) was used to measure the pupil size and center position. The offset between the pupil center and the coaxially sighted corneal light reflex (P-Dist) of the patients was recorded by the x- and y-axis eyeball tracking adjustment program of the WaveLight Eagle Vision EX500 excimer laser system (Wavelight GmbH). The patient's vision (uncorrected distance visual acuity [UDVA], best-corrected visual acuity (BCVA), and refractive power (spherical equivalent, SE) were observed preoperatively, 1 week, 4 weeks, and 12 weeks postoperatively, and a quality of vision (QoV) questionnaire was completed.

**Results** Ocular dominance occurred predominantly in the right eye [right vs. left: (178) 70.63% vs. (74) 29.37%; $p < 0.001$]. The P-Dist was $0.202 \pm 0.095$ mm in the dominant eye and $0.215 \pm 0.103$ mm in the nondominant eye ($p = 0.021$). The horizontal pupil shift was $-0.07 \pm 0.14$ mm in dominant eyes and $0.01 \pm 0.13$ mm in nondominant eyes ($p = 0.001$) (the temporal displacement of the dominant eye under mesopic conditions). The SE was negatively correlated with the P-Dist ($r = -0.223$, $p = 0.012$ for the dominant eye and $r = -0.199$, $p = 0.025$ for the nondominant eye). At

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12 weeks postoperatively, the safety index (postoperative BDVA/preoperative BDVA) of the dominant and nondominant eyes was 1.20 (1.00, 1.22) and 1.20 (1.00, 1.20), respectively, and the efficacy index (postoperative UDVA/preoperative BDVA) was 1.00 (1.00, 1.20) and 1.00 (1.00, 1.20), respectively; the proportion of residual SE within ± 0.50 D was 98 and 100 %, respectively.

**Conclusions** This study found that ocular dominance occurred predominantly in the right eye. The pupil size change was larger in the dominant eye. The angle kappa of the dominant eye was smaller than that of the nondominant eye and the pupil center of the dominant eye was slightly shifted to the temporal side under mesopic conditions. The correction of myopia in the dominant and nondominant eyes exhibits good safety, efficacy, and predictability in the short term after surgery, and has good subjective visual quality performance after correction. We suggest adjusting the angle kappa percentage in the dominant eye to be lower than that of the nondominant eye in individualized corneal refractive surgery in order to find the ablation center closest to the visual axis.

### ZUSAMMENFASSUNG

**Ziel** Untersuchung der Unterschiede zwischen dominanten und nicht dominanten Augen in einer überwiegend jungen Patientenpopulation durch Analyse des Kappa-Winkels, der Pupillengröße und der Zentrumsposition in dominanten und nicht dominanten Augen.

**Methoden** Insgesamt wurden 126 junge Studenten (252 Augen) mit Myopie, die sich einer Femtosekundenlaser-kombinierten LASIK-Operation unterzogen hatten, zufällig ausgewählt. Die okulare Dominanz wurde mit dem Loch-in-Karte-Test bestimmt. Der WaveLight Allegro Topolyzer (WaveLight Laser Technologies AG, Erlangen, Deutschland) wurde zur Messung der Pupillengröße und Zentrumsposition verwendet. Der Versatz zwischen dem Pupillenzentrum und dem koaxial gesichteten Hornhautlichtreflex (P-Dist) der Patienten wurde durch das x- und y-Achsen-Augapfel-Tracking-Anpassungsprogramm des WaveLight Eagle Vision EX500 Excimer-Lasersystems (Wavelight GmbH) aufgezeichnet. Die Sehkraft des Patienten (unkorrigierte Fernsehschärfe [UDVA], bestkorrigierte Sehschärfe [BCVA] und refraktive Leistung [sphärisches Äquivalent, SE]) wurden präoperativ, 1 Woche, 4 Wochen und 12 Wochen postoperativ beobachtet, und ein Fragebogen zur Sehqualität (QoV) wurde ausgefüllt.

**Ergebnisse** Die okulare Dominanz trat überwiegend im rechten Auge auf [rechts vs. links: (178) 70,63 % vs. (74) 29,37 %; p < 0,001]. Der P-Dist betrug 0,202 ± 0,095 mm im dominanten Auge und 0,215 ± 0,103 mm im nicht dominanten Auge (p = 0,021). Die horizontale Pupillenverschiebung betrug − 0,07 ± 0,14 mm bei dominanten Augen und 0,01 ± 0,13 mm bei nicht dominanten Augen (p = 0,001) (die temporale Verschiebung des dominanten Auges unter mesopischen Bedingungen). Das SE korrelierte negativ mit dem P-Dist (r = − 0,223, p = 0,012 für das dominante Auge und r = − 0,199, p = 0,025 für das nicht dominante Auge). Nach 12 Wochen postoperativ betrug der Sicherheitsindex (postoperative BDVA/präoperative BDVA) der dominanten und nicht dominanten Augen jeweils 1,20 (1,00, 1,22) bzw. 1,20 (1,00, 1,20), und der Effektivitätsindex (postoperative UDVA/präoperative BDVA) betrug jeweils 1,00 (1,00, 1,20) bzw. 1,00 (1,00, 1,20); der Anteil des Rest-SE innerhalb von ± 0.50 dpt betrug jeweils 98 % bzw.100 %.

**Schlussfolgerungen** Diese Studie fand heraus, dass die okulare Dominanz überwiegend im rechten Auge auftrat. Die Pupillengrößenänderung war im dominanten Auge größer. Der Kappa-Winkel des dominanten Auges war kleiner als der des nicht dominanten Auges und das Pupillenzentrum des dominanten Auges war unter mesopischen Bedingungen leicht zur temporalen Seite verschoben. Die Korrektur der Myopie in den dominanten und nicht dominanten Augen zeigt nach der Operation eine gute Sicherheit, Wirksamkeit und Vorhersagbarkeit auf kurze Sicht und hat nach der Korrektur eine gute subjektive Sehqualitätsleistung. Wir schlagen vor, den Kappa-Winkel-Prozentsatz im dominanten Auge niedriger als den des nicht dominanten Auges in der individualisierten hornhautrefraktiven Chirurgie anzupassen, um das Ablationszentrum zu finden, das am nächsten zur Sehachse liegt.

## Introduction

A dominant eye is the eye from which a person prefers to receive visual input [1, 2]. The dominant eye plays an important role in binocular visual function and clinical diagnosis and treatment of ophthalmologic disorders, such as LASIK and multifocal intraocular lens implantation and other refractive surgeries using monocular vision correction for the treatment of presbyopia, strabismus, amblyopia, nystagmus, and other clinical applications [3 – 5].

The angle kappa is defined as the angle between the visual axis and the pupillary axis [6, 7]. Pupil size and center position are important factors in personalized corneal refractive surgery [8, 9]. Now, eye-tracking technology can track the pupil center of the operative eye through the noninterference pupillary corneal reflex method, thereby estimating the direction of the visual axis. The ideal visual axis entry point, according to Pande and Hillman [10], is the coaxially sighted corneal light reflex. Therefore, angle kappa can be understood as the distance between the pupil center and the coaxially sighted corneal light reflex [11, 12]. It has become a consensus among refractive surgeons to adjust the excimer laser ablation center from the pupil center to the visual axis to compensate for the offset of the angle kappa [13]. However, whether there is a difference in the angle kappa, pupil size, and center position between the dominant eye and nondominant eye in personalized LASIK with the adjusted angle kappa is unknown.

This study explored the dynamic changes of pupil size and center position of the dominant and nondominant eye in myopic patients who were suitable for excimer laser surgery, with young college students as the main research subjects. By analyzing the offset between the pupil center and the coaxially sighted corneal light reflex (P-Dist) and relative parameters, and comparing the safety, efficacy, predictability, and visual quality of the dominant and nondominant eyes after surgery, this study clarified the dynamic changes of the pupil and angle kappa in the dominant and nondominant eye and their guiding significance for laser myopia surgery. It provides a reference for the design of LASIK in line with the optical characteristics of individual human eyes.

## Patients and Methods

We studied 252 eyes of 126 young subjects (male: 65, female: 61), with a mean age of 23.2 ± 3.5 years (range: 19 to 35 years). In all of the investigated myopic eyes, the best-corrected visual acuity (BCVA) was equal to or better than 20/20. The mean spherical equivalent (SE) was − 5.21 ± 1.27 D (range: − 0.50 D to − 10.00 D), astigmatism was less than − 1.50 D, and anisometropia ≤ 2.50 D. Ocular dominance was determined to be present in 126 (100 %) subjects. These eyes exhibited normal binocular function.

Subjects wearing their spectacles held a card with a 3-cm diameter hole in the center with both hands and viewed a target 6 meters away through the hole. One eye was then randomly covered. When the subject could not see the target, the covered eye was identified as the dominant eye. Ocular dominance was assigned to a specific eye when the subject had the same result for this series of two tests. Otherwise, another series of two tests was administered. If the second series also gave discordant results, then ocular dominance was classified as alternating. Otherwise, the eye shown to be dominant in this series was recorded as the dominant eye.

All patients underwent a preoperative ophthalmic evaluation that included autorefraction, uncorrected distance visual acuity (UDVA), BCVA, slit lamp biomicroscopy, intraocular pressure (IOP) measurement, keratometry measurements, axial length measurements, and fundus examination. Exclusion criteria: (1) suspicious keratoconus and other corneal ectatic diseases; (2) active ocular inflammation or infection; (3) cataracts, glaucoma, and significant retinal diseases affecting vision; (4) severe ocular adnexal lesions; (5) severe dry eye; (6) systemic diseases affecting the eyes. All subjects signed an informed consent form approved by the Ethics Committee of the Affiliated Hospital of Yanbian University and adhered to the principles of the Helsinki Declaration. The Wavelight Allegro Topolyzer corneal topographer (WaveLight Laser Technologies AG, Erlangen, Germany) was used to measure the position of the pupil center and pupil size. Changes in pupil diameter were measured in all subjects and recorded by a single experienced surgeon under mesopic conditions for 60 seconds; all acquisitions were performed without pupil dilation, and ambient lighting conditions were exactly the same during all measurements. The calculated pupil centroid shift was provided in the horizontal x-direction and vertical y-direction. The distance to the apex was computed by the radial distance corresponding to the x and y shifts. The pupil diameter recording mode also recorded the axis of the pupil center (the center of the cornea is the origin).

A corneal flap with a diameter of 8.5 mm and thickness of 110 mm was created using a WaveLight FS200 Hz femtosecond laser (WaveLight, GmbH, Erlangen, Germany). The patient was asked to lie flat and focus on the green indicator light. The performer could see the reflective point of the corneal vertex and the red reflection in the center of the pupil under the microscope and adjusted the lighting to keep the pupil size consistent. If the actual pupil diameter differed from the diagnostic image by more than 20 %, it was possible to modify the actual pupil size and diameter by changing the light conditions. P-Dist was recorded using the x- and y-axis eye-tracking adjustment program of the WaveLight EX500 excimer laser system (Wavelight GmbH). The 100 % P-Dist adjustments were manually entered into the excimer laser device, with the excimer laser ablation center from the pupil center to the direction of the visual axis (coaxially sighted corneal light reflex).

The 50 dominant eyes and 50 nondominant eyes were randomly selected to compare safety, efficacy, predictability, and visual quality 12 weeks after surgery. Safety, efficacy, and predictability can be evaluated by changes in the safety index, efficacy index, and residual SE. A quality of vision (QoV) questionnaire was used to evaluate visual quality. The questionnaire included nine visual symptoms such as glare, halos, starbursts, and visual haze. Each symptom included three items: frequency of occurrence, severity, and degree of disturbance. Each item could be divided into four levels from light to heavy according to the degree. To avoid misunderstandings by patients, relevant visual symptom pictures were provided during the study to help them choose.

### Statistical analysis

All analyses were performed with SPSS software (version 17, SPSS, Inc., Chicago, United States). Continuous data were reported as the mean ± SD, categorical data were reported as frequencies and percentages, and the chi-square test was used for linear trends. Changes in pupil diameter and the P-Dist between the dominant and nondominant eye were statistically evaluated with the paired t-test, and correlation with relative parameters was evaluated using the Pearson correlation test. For data that did not follow a normal distribution, the median (interquartile range) [M(P25, P75)] is used. A p value less than 0.05 was considered statistically significant.

## Results

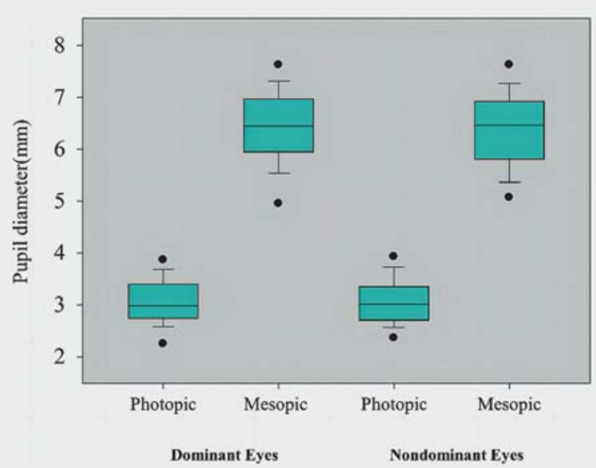
Ocular dominance occurred predominantly in the right eye (right vs. left: [178] 70.63 % vs. [74] 29.37 %; p < 0.001). The dominant eye had consistent preoperative and postoperative measurements. The mean corneal thickness was not statistically significantly different between the dominant and nondominant eyes (542.6 ± 26.5 µm vs. 544.0 ± 26.9 µm; p = 0.347). The mean anterior chamber depth was 3.25 ± 0.29 mm in the dominant eye and 3.21 ± 0.26 mm in the nondominant eyes (p = 0.126).

▶ **Table 1** shows the pupil size changes of the dominant and nondominant eye. There were no statistical differences in pupil diameter between the dominant and nondominant eye under photopic and mesopic conditions (p = 0.797 and p = 0.092, respectively). The pupil size change (mesopic − photopic pupil

▶ **Table 1** Photopic and mesopic pupil size changes in the dominant and nondominant eye.

| Category | Dominant eye | Nondominant eye | Difference | P value |
|---|---|---|---|---|
| Photopic pupil (mm) | 3.06 ± 0.49 | 3.05 ± 0.52 | 0.01 ± 0.22 | 0.797 |
| Mesopic pupil (mm) | 6.41 ± 0.74 | 6.34 ± 0.80 | 0.04 ± 0.31 | 0.092 |
| Change (mm) | 3.35 ± 0.50 | 3.28 ± 0.42 | 0.07 ± 0.25 | 0.045 |

*P < 0.05, paired t-tests




▶ **Fig. 1** Photopic and mesopic pupil diameter for the dominant and nondominant eye. The 95 % median confidence interval (external) and the interquartile intervals are shown.

▶ **Table 2** Horizontal (x) and vertical (y) pupil shift and distance to the apex for the photopic and mesopic pupil and the corresponding measured centroid shift for the dominant and nondominant eye.

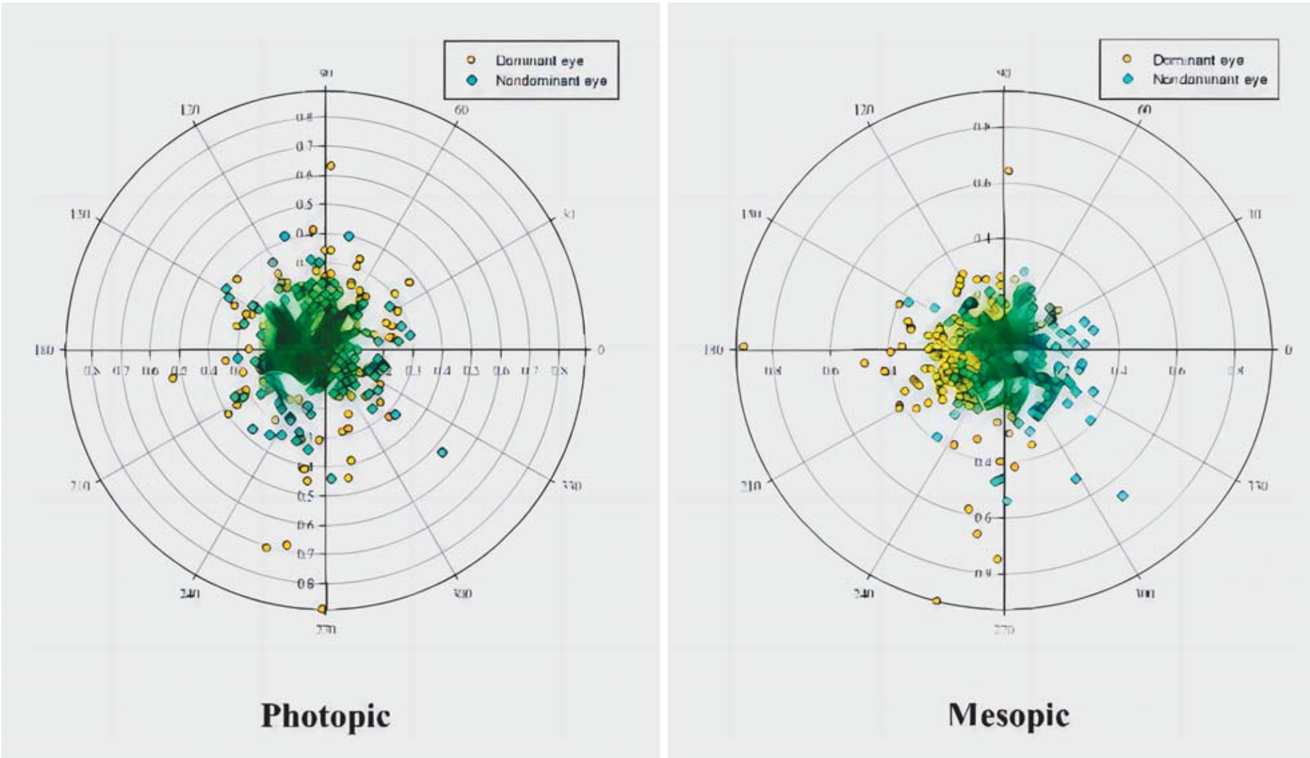
| Category | Dominant eye | Nondominant eye | P value |
|---|---|---|---|
| **Photopic pupil** | | | |
| x Shift (mm) | − 0.05 ± 0.13 | − 0.02 ± 0.14 | 0.092 |
| y Shift (mm) | 0.02 ± 0.14 | 0.01 ± 0.15 | 0.177 |
| Distance to apex (mm) | 0.18 ± 0.10 | 0.19 ± 0.10 | 0.764 |
| **Mesopic pupil** | | | |
| x Shift (mm) | − 0.07 ± 0.14 | 0.01 ± 0.13 | 0.001 |
| y Shift (mm) | − 0.02 ± 0.13 | − 0.04 ± 0.15 | 0.164 |
| Distance to apex (mm) | 0.19 ± 0.09 | 0.18 ± 0.11 | 0.701 |
| Pupil center shift | 0.304 ± 0.107 | 0.276 ± 0.169 | 0.034 |

diameter) was 3.35 ± 0.50 mm in the dominant eye and 3.28 ± 0.42 mm in the nondominant eye. The pupil size change in the dominant eye was larger than that in the nondominant eye ($p = 0.045$). ▶ **Fig. 1** shows these results in the form of boxplots.

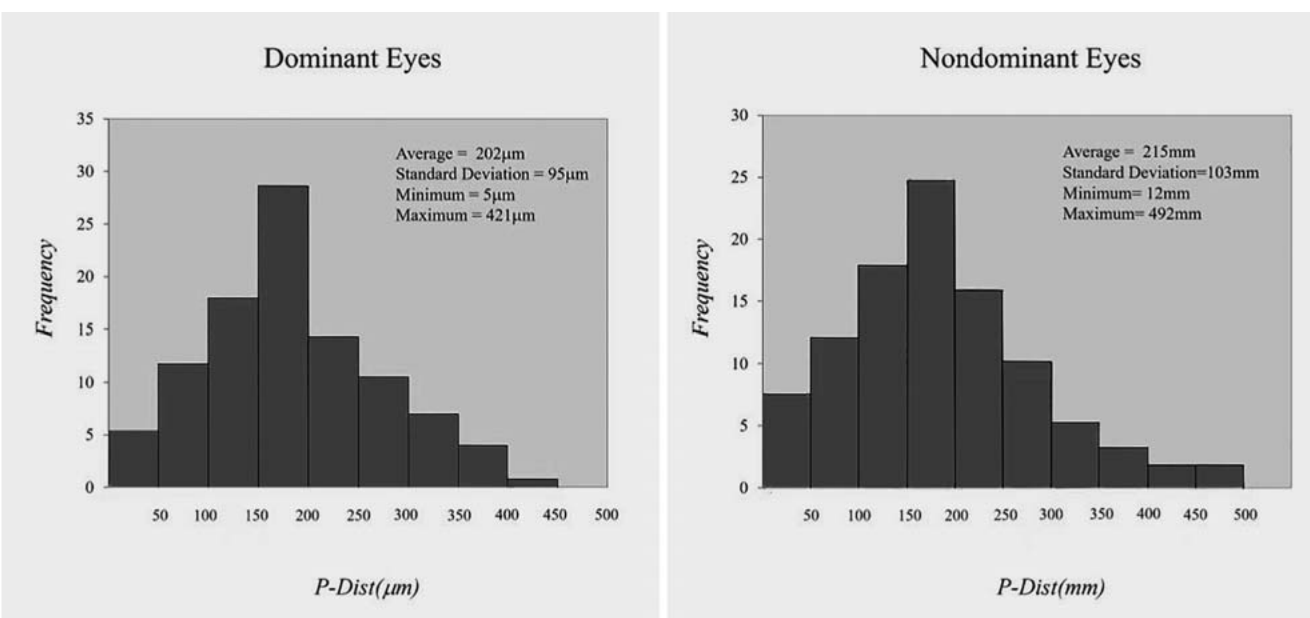
▶ **Table 2** shows the measured centroid shift, defined as the difference in distance to the apex between the photopic pupil and the mesopic pupil. There were no significant changes in horizontal (x) and vertical (y) pupil center shift of the photopic dominant and nondominant eyes ($p > 0.05$). Under mesopic conditions, the horizontal pupil shift was − 0.07 ± 0.14 mm in the dominant eye and 0.01 ± 0.13 mm in the nondominant eye ($p = 0.001$) (the temporal displacement of the dominant eye under mesopic conditions), and there were no significant differences in the vertical (y) pupil shift ($p = 0.164$; ▶ **Fig. 2**). The centroid shift of the pupil (photopic – mesopic) was 0.304 ± 0.107 mm in the dominant eye and 0.276 ± 0.169 mm in the nondominant eye, and the dominant and nondominant eyes were significantly different ($p = 0.034$).

The P-Dist histograms were bell shaped and centered on 0.20 mm with a longer right tail (▶ **Fig. 3**). The average offset distribution of P-Dist was 0.208 ± 0.098 mm (range: 0.005–0.492 mm). The P-Dist was 0.202 ± 0.095 mm in the dominant eye and 0.215 ± 0.103 mm in the nondominant eye ($p = 0.021$). For the dominant eye, the P-Dist for 35 % of eyes was ≤ 0.15 mm and for 64 % of eyes, it was ≤ 0.20 mm. For the nondominant eye, the P-Dist for 37 % of eyes was ≤ 0.15 mm and for 62 % of eyes, it was ≤ 0.20 mm. The coaxially sighted corneal light reflex tended to the temporal side of the corneal center; it was superior temporal for 34 % of the dominant eyes and inferior temporal for 29 % of nondominant eyes. The SE was negatively correlated with P-Dist for the dominant eye ($r = -0.223$, $p = 0.012$), the nondominant eye ($r = -0.199$, $p = 0.025$), and both groups combined ($r = -0.210$, $p < 0.001$; ▶ **Fig. 4**).

▶ **Table 3** shows that 12 weeks after surgery, the safety index (postoperative BDVA/preoperative BDVA) of the dominant eye group and the nondominant eye group was 1.20 (1.00, 1.22) and 1.20 (1.00, 1.20), respectively, and the efficacy index (postoperative UDVA/preoperative BDVA) was 1.00 (1.00, 1.20) and 1.00 (1.00, 1.20), respectively. There was no statistically significant difference between the two groups in terms of safety index and efficacy index ($p = 0.921$, 0.769), see ▶ **Table 3**. Twelve weeks after surgery, the proportion of patients with UDVA ≤ 0 (LogMAR) in the dominant eye group and the nondominant eye group was 100 (50 eyes) and 98 % (49 eyes), respectively, the proportion of

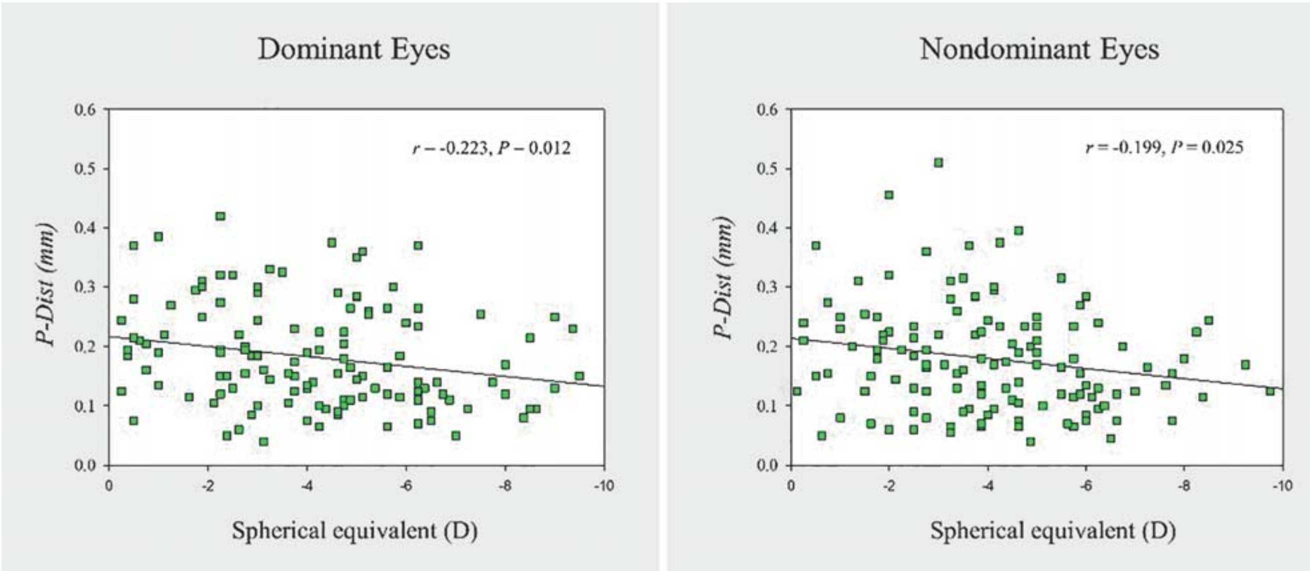



▶ **Fig. 2** Changes in pupil center position in the dominant and nondominant eye under photopic and mesopic conditions.




▶ **Fig. 3** Histogram of P-Dist (distance from pupil center to coaxially sighted corneal light reflex).

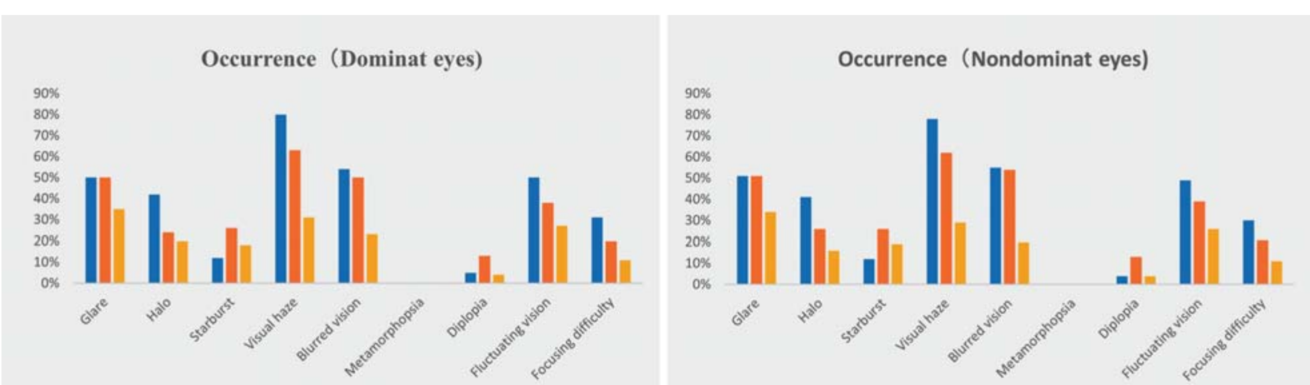
patients with postoperative UDVA equal to or better than preoperative BDVA was 82 (41 eyes) and 84 % (42 eyes), respectively, and the proportion of patients with postoperative UDVA improved by one line compared to preoperative BDVA was 34 (17 eyes) and 36 % (18 eyes), respectively; neither group had a decrease in BDVA by one line or more. During the follow-up period, all patients completed the QoV questionnaire survey. The most common visual symptom after surgery in both groups was visual haze, with a frequency occurrence of 80, 63, and 31 % at 1 week, 4 weeks, and 12 weeks after surgery), respectively, in the dominant eye group,




▶ **Fig. 4** Relationship between the SE and the P-Dist for the dominant and nondominant eye groups (r = − 0.223, p = 0.012 for the dominant eye; r = − 0.199, p = 0.025 for the nondominant eye). The P-Dist (distance from pupil center to coaxially sighted corneal light reflex).

▶ **Table 3** Comparison of visual acuity and refractive status between the two groups of patients at 12 weeks postoperatively.

| Index | Dominant eyes | Nondominant eyes | p |
|---|---|---|---|
| Sex | 50 | 50 | |
| UDVA [M (P25, P75), LogMAR] | − 0.05 (− 0.10, 0.00) | − 0.05 (− 0.10, 0.04) | 0.896 |
| BDVA [M (P25, P75), LogMAR] | − 0.10 (− 0.10, − 0.10) | − 0.10 (− 0.10, − 0.10) | 0.905 |
| Safety index [M (P25, P75)] | 1.20 (1.00, 1.22) | 1.20 (1.00, 1.20) | 0.921 |
| Efficacy index [M (P25, P75)] | 1.00 (1.00, 1.20) | 1.00 (1.00, 1.20) | 0.769 |
| Residual spherical equivalent | 0.03 ± 0.32 | 0.02 ± 0.36 | 0.857 |




▶ **Fig. 5** Postoperative visual symptoms and frequency of occurrence in the two groups of patients.

and a frequency occurrence of 78, 62, and 29% at 1 week, 4 weeks, and 12 weeks, respectively, after surgery in the nondominant eye group (see ▶ **Fig. 5**). The severity of visual symptoms and their degree of disturbance to patients were mostly mild or less. Patient satisfaction was high after surgery, with 98 and 100% of patients in the dominant eye group and nondominant eye group, respectively, reporting significant or great improvement in visual quality after surgery.

## Discussion

Currently, angle kappa adjustment is a vector percentage compensation between the pupil center and the coaxially sighted corneal light reflex. However, it does not account for the dynamic changes of the pupil, dominant eye, and other factors. Studies have shown that ideal angle kappa compensation should change with the dynamic changes of the pupil [14]. The size and central position of the pupil can be affected by various factors such as light intensity, emotional tension, surgical stimulation, and close gaze at indicator lights [15]. To determine if the individualized angle kappa adjustment can be obtained according to the dynamic change data of the angle kappa of the dominant and nondominant eyes, and if the ablation center point closest to the visual axis can be found to ensure that each excimer laser spot is hit at the correct position, it is necessary to deeply study the dynamic changes of the pupil and angle kappa of the dominant and nondominant eyes in patients undergoing excimer laser myopic surgery. This has significant implications for the design of personalized refractive surgery.

In our study, we found that ocular dominance occurred predominantly in the right eye ($p < 0.001$). The pupil size change in the dominant eye was larger than that in the nondominant eye ($p = 0.045$). Under mesopic conditions, the horizontal pupil shift was significantly different between the dominant and nondominant eyes ($p = 0.001$). The centroid shift of the pupil was also significantly different between the dominant and nondominant eyes ($p = 0.034$). The P-Dist was significantly different between the dominant and nondominant eyes ($p = 0.021$). The SE was negatively correlated with P-Dist for the dominant eye ($p = 0.012$), the nondominant eye ($p = 0.025$), and both groups combined ($p < 0.001$).

However, we also found some results that were not significant. The mean corneal thickness was not statistically significantly different between the dominant and nondominant eyes ($p = 0.347$). The mean anterior chamber depth was also not statistically significantly different between the dominant and nondominant eyes ($p = 0.126$). There were no statistical differences in pupil diameter between the dominant and nondominant eyes under photopic and mesopic conditions ($p = 0.797$ and $p = 0.092$, respectively). There were no significant changes in horizontal (x) and vertical (y) pupil center shift of the photopic dominant and nondominant eyes ($p > 0.05$). There were also no significant differences in the vertical (y) pupil shift under mesopic conditions ($p = 0.164$).

The present study indicates that ocular dominance occurred predominantly in the right eye (70.63 %), which is consistent with other reports [16 – 18]. In this study, the average P-Dist was 0.208 ± 0.098 mm, the minimum was 0.010 mm, and the maximum was 0.580 mm. The P-Dist for the dominant eye was 0.202 ± 0.095 mm, and that for the nondominant eye was 0.215 ± 0.103 mm. The dominant eyes had a smaller angle kappa than the nondominant eyes. The coaxially sighted corneal light reflex shifted mainly to the temporal side of the corneal center, and it was mainly distributed in the superior temporal region for dominant eyes and in the inferior temporal region for nondominant eyes. The pupil size of the nondominant eye was smaller than that of the dominant eye, but there was no significant difference. In general, the angle kappa is relatively small in myopic eyes, which means that the visual axis and the center of the pupil are relatively close. As a result, during myopic ablation, the laser can accurately target the central part of the cornea, creating a larger optical zone, resulting in a flatter and more uniform corneal curvature after ablation.

Comparison of pupil diameter indicated no significant differences between dominant and nondominant eyes. The present study found a significant association of myopia and the dominant eye in regard to photopic and mesopic pupil size change. We found that the pupil size change corresponded to 3.35 ± 0.50 mm for dominant eyes and a 3.28 ± 0.42 mm relative reduction for nondominant eyes; the pupil size change of dominant eyes was greater than that of nondominant eyes. We speculate that the dominant hemisphere of the brain may affect which eye is held closer to the plane of the near task, especially when writing. Because of the inconsistent fixation distance, the nondominant eye in the accommodative response of two eyes in binocular viewing of real targets needs more accommodation to achieve the same vision status as the dominant eye, resulting in a larger angle kappa relative to the dominant eye [19 – 21]. However, there is currently not enough evidence to determine whether these changes are congenital or acquired [22, 23]. Cheng et al. [24] found that the dominant eye plays a primary role in accommodation in binocular viewing, resulting in greater defocus compared with nondominant eyes in myopia. The pupil center (x-axis) of the dominant eye was − 0.07 mm and that of the nondominant eye was 0.01 mm. The pupil centers of the nondominant eye were basically distributed around the center of the cornea, and those of the dominant eye were 0.08 mm more temporal than for the nondominant eyes. Theoretically, the larger the angle kappa, the greater the distance between the pupil center and the coaxially sighted corneal light reflex [25, 26].

In this study, the angle kappa of nondominant eyes was greater than that of dominant eyes. The center position and angle kappa of dominant and nondominant eyes could be evaluated, and the individual angle kappa adjustment vector percentages could be obtained to find the ablation centration point closest to the visual axis. The pupil center difference between the dominant and nondominant eyes guides operations so that the ablation center of the dominant eye is positioned as far as possible from the center of the cornea, slightly to the temporal side, within − 0.07 mm, such as in the pupil center. When the percentage of the angle kappa adjustment vector is individualized, it is suggested that the proportion of the angle kappa adjustment in dominant eyes is lower than that in nondominant eyes [27 – 29].

Both groups had good safety, effectiveness, and predictability in the short term after eye surgery. Both groups had visual symptoms after surgery, with visual blurring being the most common, but overall patient satisfaction was high and postoperative objective visual quality performance was good.

**CONCLUSION BOX**

**Already known:**

- Pupil changes in dominant eyes are slightly different from those in nondominant eyes.
- Accurate positioning of the excimer laser cutting center for dominant and nondominant eyes is crucial.
- Further research is needed to study angle kappa compensation and wavefront aberrations of dominant and nondominant eyes.

**Newly described:**

- Under mesopic conditions, the pupil center of the dominant eye is slightly shifted to the temporal side.
- In individualized corneal refractive surgery, adjusting the angle kappa percentage in the nondominant eye to be higher than that of the dominant eye may be beneficial for UDVA, predictability, effectiveness, safety, and quality of vision.
- Further research is needed to study angle kappa compensation and wavefront aberrations of dominant and nondominant eyes, and the digital correspondence between personalized ablation of various modes remains to be further explored.

## Conflict of Interest

The authors declare that they have no conflict of interest.

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