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ORIGINAL ARTICLE

# Surgical approach affects intraocular lens decentration

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**KEYWORDS**
intraocular lens decentration;
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*Background/purpose:* This study aims to quantify and identify risk factors for intraocular lens (IOL) tilt and decentration early after surgery using Scheimpflug imaging.
*Methods:* We prospectively included 268 eyes of 253 patients who underwent uneventful cataract surgery and one-piece IOL implantation using a superior or temporal approach. Scheimpflug imaging was used to evaluate the tilt and decentration of IOLs at 1 week, 1 month, and 3 months postoperatively. Differences in IOL tilt and decentration between the approaches were examined. Correlations of age and axial length with the magnitudes of IOL decentration and tilt were also examined.
*Results:* In total, 139 right and 129 left eyes were included. IOL displacement averaged 150 μm upward and 150 μm to the nasal side of the pupil. Over 50% of the eyes were tilted upward and approximately 90% to the temporal side. The surgical approach was significantly associated with horizontal decentration in both eyes, but significantly associated with only vertical decentration in the right eye 1 week postoperatively. In the left eyes, IOLs were shifted to the nasal side in 57.1% and 36.8% of the eyes that received the temporal and the superior approach, respectively, compared with 75.8% and 50% in the right eyes. The differences were significant only at 1-week follow-up ($p = 0.035$ and $p = 0.003$, respectively). Age or axial length was not associated with IOL tilt or decentration in either eye.
*Conclusion:* Scheimpflug imaging can be used as a quantitative tool to evaluate IOL position. The incision site affected the IOL position, this finding was significant at 1 week postoperatively only.


Conflicts of interest: The authors have no conflicts of interest relevant to this article.

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## Introduction

Intraocular lens (IOL) decentration and tilt can lead to astigmatism, change in optical higher-order aberrations, and loss of best-corrected visual acuity.[1,2] Accurate IOL position is even more important in this era of premium IOLs. Although the incidence of IOL misalignment has been substantially reduced due to the improvements of surgical techniques and IOL designs, it can still occur even after an uneventful surgery.[3] While there have been many methods to measure IOL position including ultrasound biomicroscopy, Scheimpflug images, Purkinje reflections, photographic documentation, and anterior segment optical coherence tomography (OCT),[4–8] only a few studies have been able to identify the risk factors associated with IOL decentration and tilt, especially in the early postoperative period. The purpose of this study was, therefore, to document postoperative IOL decentration and tilt after uneventful phacoemulsification using Scheimpflug imaging. We further investigated the possible factors associated with IOL decentration and tilt.

## Materials and methods

### Patients

This prospective study recruited Taiwanese patients older than 55 years who had uneventful phacoemulsification with IOL insertion. This study was approved by the Institutional Review Board/Ethics Committee of the Far Eastern Memorial Hospital and was conducted in accordance with the tenets of the Declaration of Helsinki. The exclusion criteria included uveitis, posterior synechia, history of ocular surgery or trauma, lens subluxation, and zonule dehiscence that was found before or during the surgery. Patients with surgical complications including anterior radial tear, posterior capsule rupture or anterior capsule that did not totally cover the IOL were also excluded. A total of 286 eyes of 271 patients were enrolled in this study. All patients received a full ophthalmic examination, including visual acuity, autorefraction (KR 8900; Topcon, Tokyo, Japan), noncontact pneumotonometry (CT-80; Topcon, Oakland, CA, USA), slit-lamp examination, and indirect ophthalmoscopy, before and after the surgery. Axial length was measured with the IOL Master V4.8 (Zeiss, Oberkochen, Germany). Measurement of IOL centration with Scheimpflug imaging (Pentacam HR; Oculus, Wetzlar, Germany) was performed 1 week, 1 month, and 3 months after surgery. The position of the patient's head was confirmed to be straight and centrally located. All the examinations were performed according to the manufacturer's instruction and performed by a single well-trained technician.

### Surgical procedures

All surgeries were performed by one of four experienced surgeons. Two surgeons (P.Y.C. and J.K.W.) used the temporal approach and two (P.Y.S. and S.W.C.) the superior approach. A continuous curvilinear capsulorrhexis measuring approximately 5.5 mm in diameter was created. Phacoemulsification was performed using a standardized technique. The capsulorrhexis overlapped the IOL optic in all cases. IOL implantation into the capsule bag was performed with an injector. The two kinds of IOLs used in our study [single-piece acrylic AcrySof IOL (Alcon, Texas, TX, USA) and single-piece Tecnis ZCB00 aspheric IOL (Abbott Laboratories Inc., Chicago, IL, USA)]. Both have a 13.0 mm haptic length and a 6.0 mm optic diameter.

### Postoperative measurements with Pentacam HR

The Scheimpflug imaging system was used to evaluate IOL tilt and decentration. Algorithms that work directly on the raw images to correct geometric distortion and calculate IOL tilt and decentration were developed following the method of de Castro et al.[7] Briefly, the geometrical distortion of the anterior segment image caused by the tilt of the object plane with respect to the optical axis of the Pentacam image was first corrected. Edges of the cornea, iris, and IOL were detected by the custom code written in Matlab (Appendix 1). The closest curves of the cornea, iris, and IOL were fit by the least squares method. The line crossing the midpoint of the intersection of the two fitting curves of the anterior and posterior IOL edges was defined as the IOL center and the perpendicular line was defined as IOL axis. The line connecting the centers of the anterior corneal surface and the pupil was defined as the visual axis. IOL decentration was calculated as the distance between the IOL axis and the IOL center. IOL tilt was defined as the angle between the IOL axis and the visual axis. IOL decentration was obtained from the distance between the IOL center and the pupillary axis. The patients for whom the Scheimpflug imaging system failed to get a clear image were excluded from the analysis; a total of 18 eyes (6.29%) were excluded.

Figure 1 shows the definition of a positive or negative sign for the direction of IOL decentration and tilt. By eliminating the positive and negative signs, magnitudes of horizontal and vertical decentration can be determined without reference to the nasal/temporal and superior/inferior orientation, respectively. By eliminating these positive and negative signs, magnitudes of horizontal and vertical tilt can be determined without reference to any orientation. All measurements were performed by the same technician (C.Y.L.).

### Statistical analysis

Descriptive statistics, including the number for categorical data, mean and standard deviation, and frequency for continuous data, was used to show data distributions. Multivariate regression analysis adjusted by age and sex was used to find the possible factors associated with IOL decentration and tilt. As values of outcome variables (decentration and tilt on the $x$- and $y$-axis) can be either positive or negative, we analyzed them separately by taking the absolute and raw values of the outcome variables. The original value was used to preserve the direction of data, and find the relationship between variables and the direction of IOL decentration and tilt. The absolute value was used to derive the relationship between variables and the amount of IOL decentration and tilt. In all analyses, $p$ values of $<0.05$ were considered to indicate statistical significance. The Chi-square test was used to determine the difference in $x$ and $y$ decentration between superior and