·Clinical Research·

Using LaserSight Astrapro Planner 2.2 Z software in corneal topography-guided laser *in situ* keratomileusis for myopia with asymmetric corneal shape

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Abstract

• AIM: To determine the clinical outcomes of laser *in situ* keratomileusis (LASIK) treatments using LaserSight AstraPro Planner 2.2 Z software for myopia with asymmetric corneal shape.

• METHODS: Four hundred and eighty-five eyes [243 patients; spherical equivalent (SE), -5.93±1.88 diopters (D)] were treated with asymmetric ablations using LaserSight SLX laser (version 5.3, 300Hz) were retrospectively analyzed and LaserSight AstraPro Planner 2.2 Z software. Preoperative and postoperative uncorrected visual acuities (UCVA), spherical equivalent (SE) refraction, pachymetry, and corneal asphericity (Q value) and decentration were evaluated.

• RESULTS: At 12mo postoperatively, the decimal UCVA was 1.0 or better in 449 (92.6%) eyes. Two eyes (0.4%) lost 1 line of the decimal best spectacle-corrected visual acuity (BCVA), 316 (65.2%) did not change, 149 (30.7%) gained 1 line, and 18 (3.7%) gained 2 lines or more after surgery. Three hundred and thirty-two eyes (68.5%) were within 0.5 D in SE. The mean tissue saving ablation depth was 4.28±2.86 (0-16) μm (median, 4 μm). The mean attempted remaining central corneal thickness was 435.79 ±29.56 μm, the mean postoperative pachymetry was 444.94 ±28.93 μm. The mean preoperative Q value was -0.19 ±0.18, the postoperative was 0.30 ±0.48 (P= 0.000). The mean postoperative decentration was 0.39 ± 0.19 mm.

• CONCLUSION: Topography-guided LASIK with AstraPro Planner 2.2 Z custom ablation planning software in an asymmetric ablation mode was an effective, safe, predictable, and stable refractive procedure for the myopia with asymmetric corneal topography.

• **KEYWORDS:** myopia; laser *in situ* keratomileusis; corneal topography; asymmetric ablation

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INTRODUCTION

According to color-coded topographic maps, patterns of corneal anterior surface include round, oval, symmetric bow tie, asymmetric bow tie, and irregular shapes. Bogan *et al*[1] reported 32.1% (128/399) of eyes in 212 subjects had the asymmetric bow tie topography. Liu *et al*[2] showed 11 eyes with asymmetric bow tie shapes in 46 eyes of 46 normal subjects. In addition to the asymmetric bow tie configuration, round, oval, and irregular corneal shapes were observed during pre-operative examination.

LaserSight AstraPro Planner 2.2 Z software is based on cornea topography/elevation data [3]. The Z-axis is defined as the axis passing through the corneal vertex. The target Z-axis can be micro-translated to achieve an asymmetric ablation zone around the visual axis using software designed for the asymmetric anterior cornea. This special ablation model is beneficial to the asymmetric corneal anterior surface. After target Z-axis micro-translation and asymmetric ablation, some central corneal tissues could be saved and symmetric corneal anterior surfaces obtained postoperatively. We used LaserSight AstraPro Planner 2.2 Z software and the SLX excimer laser system (version 5.3, 300 Hz) to treat 485 myopic eyes (243 patients). All eyes had asymmetric shapes on corneal anterior surfaces showed by AstraMax topographer (LaserSight Technologies, Inc., FL, USA). This study analyzed the pre- and postoperative outcomes, and evaluated the efficacy, predictability, stability, and safety of this surgical procedure.

SUBJECTS AND METHODS

We retrospectively reviewed data from 485 eyes obtained following LASIK surgery performed by a single surgeon

between April 2006 and April 2011. All patients had a minimum of 12mo of follow-up after surgery. If a patient's Astramax topography showed an asymmetric corneal anterior surface in one or two eyes, the same AstraPro Planner 2.2 Z software was used in both eyes. Patients were also eligible for inclusion in the study according to the following criteria: stable myopia or myopic astigmatism; age of at least 18y; spherical equivalent (SE) between -1.0 D and -12.0 D; no ocular disease such as glaucoma, corneal dystrophy, regionally retinal detachment and *etc*; no previous refractive surgery; and no systemic disease likely to affect corneal wound healing. Patients had completed preoperative examinations, including assessment of clinical manifestations and medical history, measurement of the decimal uncorrected visual acuity (UCVA), intraocular pressure (IOP), refractive error (auto-refractometer RM.8000B, Topcon Co., Japan), manifest and cycloplegic refractions, the decimal best spectacle-corrected visual acuity (BCVA, every eye reached 1.0 in dimly and lit rooms), and pachymetry (minimum value from ten measurements) by ultrasonic pachymeter (pachymeter SP-3000, Tomey Co., Japan); corneal posterior surface by Pentacam topography (Oculus, Inc) to avoid postoperative keratoconus and corneal ectasis; measurement of scotopic pupil size; slit-lamp biomicroscopic examination; and dilated fundus examination. Corneal anterior surface asphericity (Q value) and decentration were derived from Astramax topography data. Subjective night vision symptoms were also recorded. The study protocol was approved in advance by the medical ethics committee of Air Force General Hospital. For all study procedures, the tenets of the Declaration of Helsinki were followed. Written informed consents were received from all patients before treatments.

Laser Ablation Profile Before surgery, every eye had at least 4 photopic pupil images taken by AstraMax topography. On the Astralink Export platform, photopic pupil images were calculated and "Std. Dev" maps were used to choose the three most similar maps to generate average data The average corneal data was analyzed using AstraPro Planner 2.2 Z software installed in the topographer. The estimated flap thickness was 150 μm using a 110 microkeratome head (Moria2 microkeratome, Moria Inc., France) and 130 μm when using a 90 microkeratome head (Moria2 microkeratome, Moria Inc., France). We adjusted the target corneal Q value to the largest -0.9 to maintain a prolate corneal shape. The target remaining central bed thickness was at least 270 μm. The target refraction was 0 and the vertex was 12 mm. According to the refraction and pachymetry, 5.5-6.6 mm optical zone (OZ) and 6.5-7.6 mm treatment zone (TZ) were selected. All operations were performed by the same surgeon (Liu B). The LaserSight laser system works at a repetition rate of 300 Hz and produces a spot size of 0.5 mm. An active pupil tracking system was used, and the automatic measure system helped the surgeon adjust the offset.

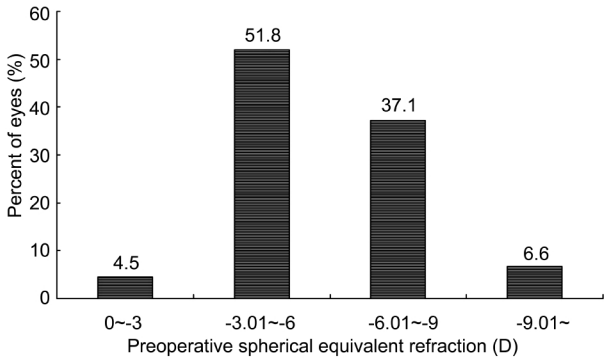

Figure 1 Preoperative spherical equivalent refraction.

Surgical Technique The eyedrops administered before surgery consisted of topical 0.5% levofloxacin eye drops (Santen, Osaka, Japan) and sodium hyaluronate eye drops (Santen, Osaka, Japan) 4 times daily for at least 3d, respectively. After topical anesthesia with 2 drops of benoxil 0.4% solution (oxybuprocaine hydrochloride eye drops, Santen, Japan) instilled 3 times, the cornea was exposed with an eyelid speculum. The cornea was cleared with a balanced salt solution (BSS, Alcon, Fort Worth, Texas) at 4℃. The offset was determined by the pupil measure system under the same background brightness used during the laser procedure. The flaps were created with a superior hinge using a Moria2 microkeratome. The excimer laser ablation was performed under pupil-based eye tracking system. The flaps were repositioned following irrigation with BSS. Postoperatively, 0.1% fluorometholone eye drops (Allergan Inc., Irvine, CA, USA) were used 4 times daily, and gradually tapered to once per day at intervals of 1wk for 4wk. Levofloxacin 0.5% eye drops were given 4 times per day for the first postoperative week and sodium hyaluronate eye drops 4 times daily for about 2mo.

Follow-up The follow-up was routinely performed at 1, 3, 6 and 12mo after surgery. Postoperative examinations included measurement of the decimal UCVA, manifest refraction, pachymetry, and IOP; slit-lamp biomicroscopy; fundus examination. Adverse events, operative/postoperative complications and patient symptoms were all recorded. All examinations were performed in a masked manner.

Statistical Analysis All patients' information from preoperative examination, treatment details, and postoperative examination were analyzed using SPSS for Windows software (version 10.00, SPSS, Inc.). Paired t tests were used to compare postoperative versus preoperative results. All P values were 2 tailed and were considered statistically significant if less than 0.05.

RESULTS

Of the 243 patients, 68 were men and 175 were women. The mean preoperative manifest SE was -5.93 ±1.88 (-11.75-

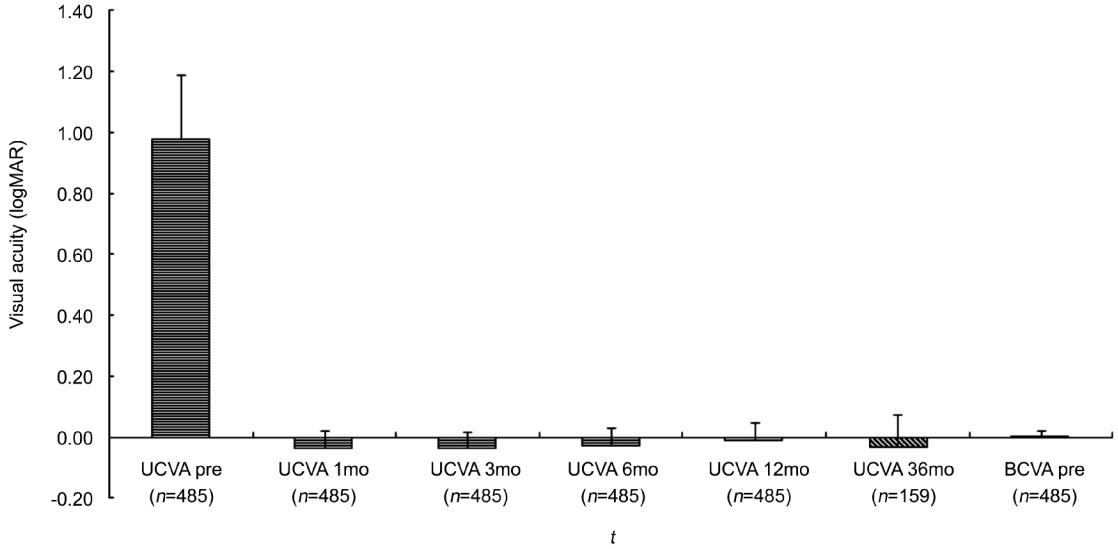

Figure 2 Uncorrected visual acuity (UCVA) and best spectacle–corrected visual acuity (BCVA) before LASIK surgery and UCVA after LASIK surgery.

-1.125) D (Figure 1), the median of saving ablation depth was 4 μm, and Table 1 shows preoperative data. The mean attempted remaining central corneal thickness was 435.79±29.56 (392-559) μm, postoperative pachymetry was 444.94±28.93 (392-561) μm, and the both paired samples correlation was 0.897 (P>0.001). The mean postoperative Q value was significantly positive to 0.30±0.48 (-1.16-2.14) (t=-18.88, P=0.000).

The mean postoperative decentration was 0.39±0.19 (0-0.82) mm. The majority of decentrations (89.9%, 436/485) were mild (less than 0.5 mm), 10.1% of the decentrations (49/485) were moderate (between 0.5 and 1.0 mm), and none were severe.

Efficacy After LASIK surgery, UCVA improved significantly (t=100.5, P=0.000) from 0.98±0.21 (logMAR notation, mean±SD) preoperatively to -0.01±0.06 at 12mo follow-up (Figure 2). The UCVAs were 1.0 (decimal) or better in 456 eyes (94.0%) at 6mo and in 449 eyes (92.6%) at 12mo.

Safety None of the examined eyes lost more than 1 line of BCVA at 12mo (Figure 3). Two eyes (0.4%) lost 1 line, 316 (65.2%) did not change, 149 (30.7%) gained 1 line, 18 (3.7%) gained 2 lines or more after surgery.

Predictability The mean postoperative SE was -0.11±0.66 D (range: -3.25-1.5) at 6mo, and -0.21±0.66 D (range: -4.25-1) at 12mo. Four hundred and thirty eyes (88.7%) were within 1 D of the aimed-for refractive change, 332 eyes (68.5%) were within 0.5 D, 224 eyes (46.2%) were within 0.25 D. The eyes with high myopia were easily under-corrected (Figure 4).

Stability The change of mean SE between 1 and 3mo was -0.2 D, that between 3 and 6mo was -0.17, and that between 6 and 12mo was -0.1 D (Figure 5). The overall regression was 0.47 D.

Table 1 Preoperative data

Parameter	Mean±SD	Range
Age (a)	26.51±5.93	18-46
Sphere (D)	-5.56±1.83	-11.00-0
Cylinder (D)	-0.74±0.65	-4.25-0
Pachymetry (μm)	537.58± 27.76	489-619
Attempted ablation depth (μm)	101.79±21.04	35-155
Saving ablation depth (μm)	4.28±2.86	0-16
X-axis micro-translation (μm)	8.30±11.50	0-36
Y-axis micro-translation (μm)	11.90±8.50	0-37
Q value	-0.19±0.18	-0.9-0.68

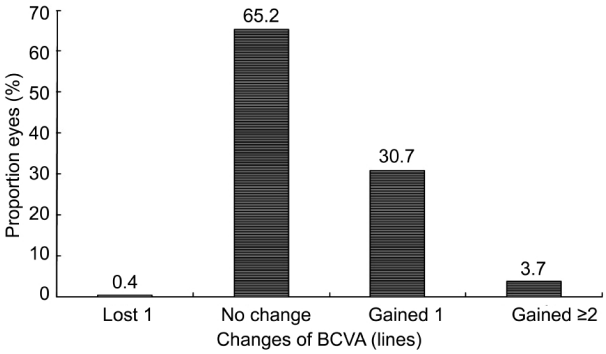

Figure 3 Changes in best spectacle –corrected visual acuity (BCVA) at 12mo.

DISCUSSION

Using a topography elevation for the laser ablation plan should be an ideal method to retreat the irregular corneal surface after primary corneal refractive surgery [4-6]. Different excimer laser systems have laser ablation modes to correct irregular corneal surfaces in order to restore centered ablation zones and improve the efficacy and safety [7-11]. Most of them apply corneal anterior surface elevation data to determine the laser scanning procedure [12-16]. Liu and Wu[17,18] applied the AstraPro 2.2 Z software to retreat decentered laser ablations and successfully modify optical center by

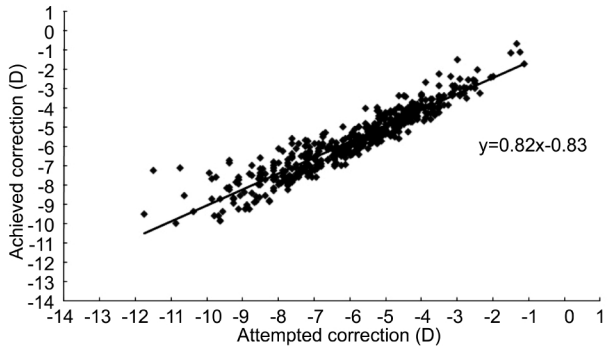

Figure 4 Attempted versus achieved correction of spherical equivalent 12mo after LASIK using AstraPro Planner 2.2 Z software.

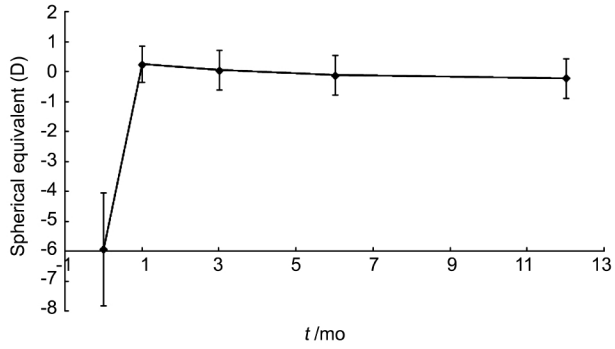

Figure 5 Time course of the postoperative spherical equivalent and standard deviation.

target Z axis micro-translation. At the same time, the central corneal tissue was saved and corneal surfaces were normalized.

In this study, we used the software for primary excimer laser corneal refractive surgery in myopic patients. In their primary LASIK treatment plans, all of the target Z-axes were optimized and some central treatment depths were reduced greatly. The largest saving ablation depth was 16 μm. Saving 10 μm or more ablation depth was accomplished in 27/485 eyes (5.57%) and 5 μm or more in 202/485 eyes (41.65%). Saving 10% or more of central ablation depth was accomplished in 29/485 (5.98%) eyes while 5% -10% occurred in 144/485 (29.69%) eyes. The high correlation (r=0.897, P> 0.001) of mean attempted remaining central corneal thickness and postoperative pachymetry indicated central corneal tissues were spared. We found that the software was a better choice for thinner corneas with asymmetric anterior surfaces.

Although the target Q value was adjusted to -0.9, the postoperative mean Q value was also positive, indicating laser cornea refractive surgery changed its shape especially in high myopia. Mild and moderate decentration cases were also detected by the topographer. To avoid glare at night from decentered ablation, our clinical recommendations are, first, the ablation size should be as large as possible, postoperative refractive status and vision quality are more

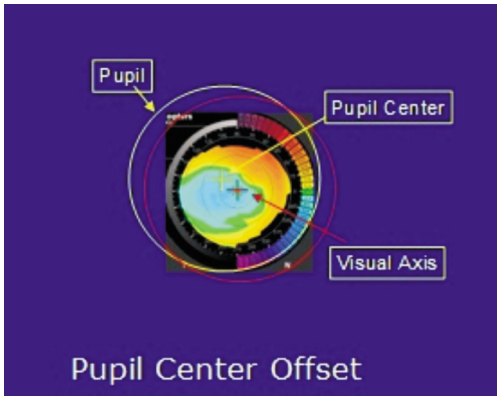

Figure 6 In an active pupil tracking system, it is important that the laser scanning center is close to corneal reflection spot of the visual axis by offset adjustment to avoid decentered ablation.

stable and better with a bigger optical and treated zone. Secondly, the offset adjustment is very important in topography-guided laser ablation. The laser scanning should be conducted along the visual axis (Figure 6). As the pupil center changes with the pupil size, the background brightness during measuring offset should be the same as that during laser ablation in order to minimize this difference. The offset should be determined repeatedly and a minimum value with a minimum pupil size should be chosen to avoid over-shifting. We noticed it was important to train patients to fixate on the red fixation light and relax completely, because a patient fixation change could influence the offset measured during laser ablation. Corneal limbus and iris should be ideal marks to lock the Y-axis[19-21].

In conclusion, primary Q-value and topography-guided LASIK with AstraPro Planner 2.2 Z custom ablation planning software in an asymmetric ablation mode was an effective, safe, predictable, and stable refractive procedure for treating myopia with asymmetric corneal topography. The central corneal thicknesses could be spared more in cases with asymmetric corneal anterior surface shapes. The eye tracking system of LaserSight SLX excimer laser (version 5.3, 300Hz) system should be further improved.

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Conflicts of Interest: Liu B, None; **Chen W,** None; **Shao DW,** None; **Wang H,** None; **Ru HX,** None; **Zhang M,** None; **Wang Y,** None; **Yang CY,** None.

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