Site-Specific Adjustment of Post-Operative Induced Aberration for LASIK Refractive Surgery

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Purpose

It is well known that a LASIK procedure may induce HOAS, in particular spherical aberration (SA). Generally, higher refractive correction is associated with higher levels of SA induction (See Figure 1). These changes overlap with aberrations that arise during corneal healing and should be taken into account for more precise treatment planning. Flap-induced aberrations may be measured directly by replacing the flap and measuring prior to the ablation. Or, they may be estimated using statistical methods. We propose a statistical technique to predict aberrations that may be induced by flap creation and to use the results to adjust the treatment target.

Background

Although the LASIK treatment algorithm is the same for all treatments, clinical outcomes are also influenced by many variables including surgeon skill, calibration, energy fluctuation of the laser; eye tracking and treatment registration; and type of correction.

Given a large clinical data set, a linear regression may be employed to adjust the algorithm to compensate for variables. For low-order aberrations the adjustment may be achieved by scaling the ablation target depth. Figure 1 shows attempted versus achieved manifest refraction in spherical equivalent (MRSE) before and after algorithm adjustment.

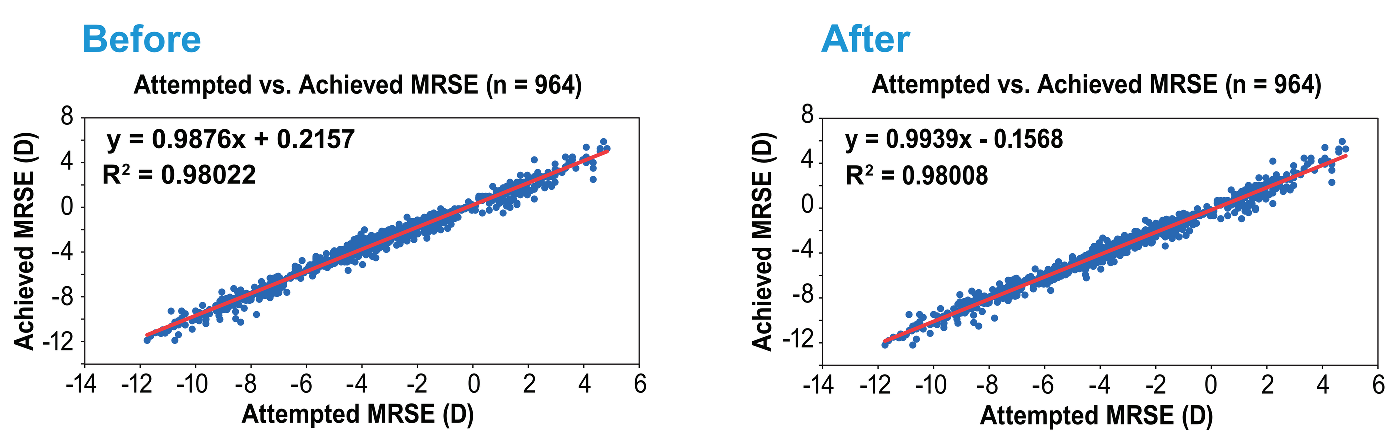


Fig. 1. Attempted vs. achieved MRSE before (left panel) and after (right panel) an algorithm adjustment is applied.

No similar algorithm adjustment has been implemented for high order aberrations (HOA) that takes into account the normalized differences described above. This study aims at compensating for surgical site or surgeon variability as a factor in the induction of spherical aberration (SA).

Methods

Generally, higher refractive correction is associated with higher levels of SA induction, as shown in Fig. 2.

Flap-induced SA can be assessed by statistical analysis of a large population. However, a more accurate treatment model could be created by including the relationship of the flap-induced SA to site-specific surgical variables.

The regression trend line of induced SA as a function of the pre-operative MRSE typically crosses the y-axis at some non-zero level: SA_0. This value quantifies the change in SA when only a flap is created and no ablation is performed. The flap-induced aberrations may also be derived from a flap-creation model that takes into account site-specific parameters.

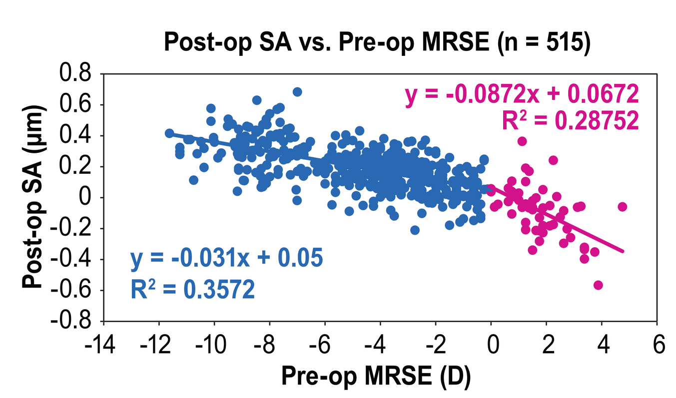


Fig. 2. Post-operative SA as a function of pre-operative MRSE for myopia and hyperopia. The regression lines do not cross zero, which indicates a flap-induced SA for a zero refractive correction.

The value of SA_0 may depend on multiple factors, including the difference between flaps created by microkeratome vs. femto-second laser,[1,2] individual surgeons' techniques, operating environment, etc.

Results

For this study, we analyzed patient demographics and surgical parameters of more than 1000 eyes from multiple clinical studies. Figure 3 shows the estimated flap-induced SA for different clinical sites. A number of sites do not achieve statistical significance for the intercept when the regression is studied between the post-operatively induced SA and the pre-operative MRSE. At sites A, D, and E the intercept is statistically significant. The intercept for the regression lines for these sites is a positive number, indicating induction of positive SA. The corresponding regression scatter plots for sites A and E are shown in Fig. 4.

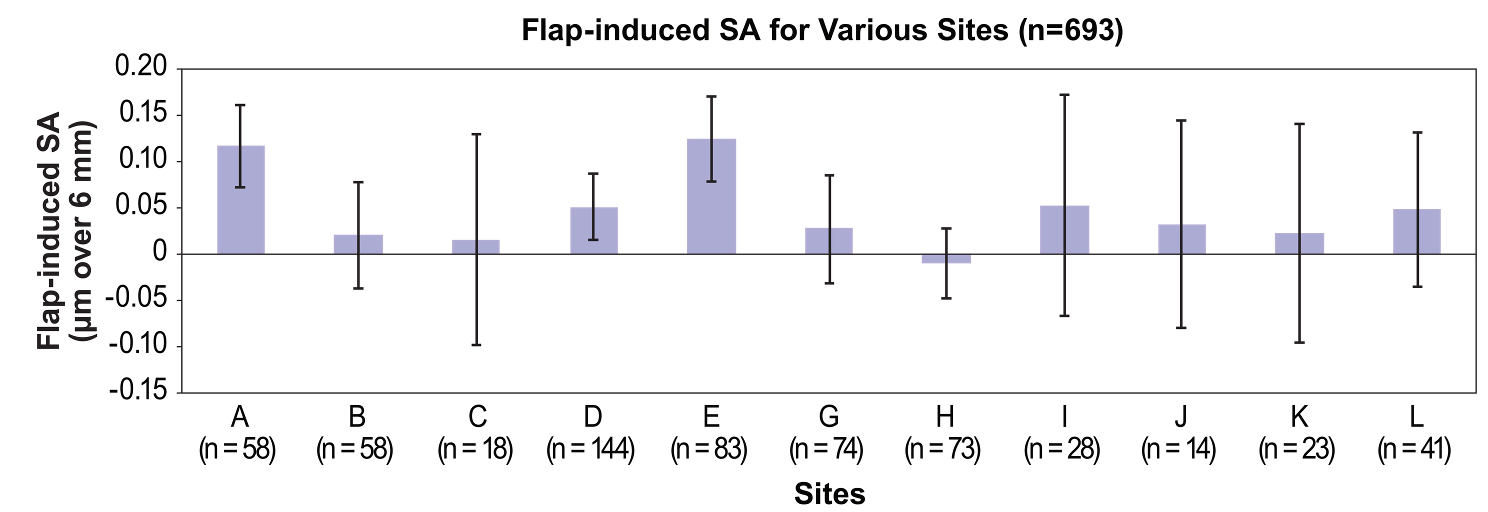


Figure 3. Regression intercept (flap-induced SA) from scatter plots between post-operative SA and pre-operative MRSE for various clinical sites.

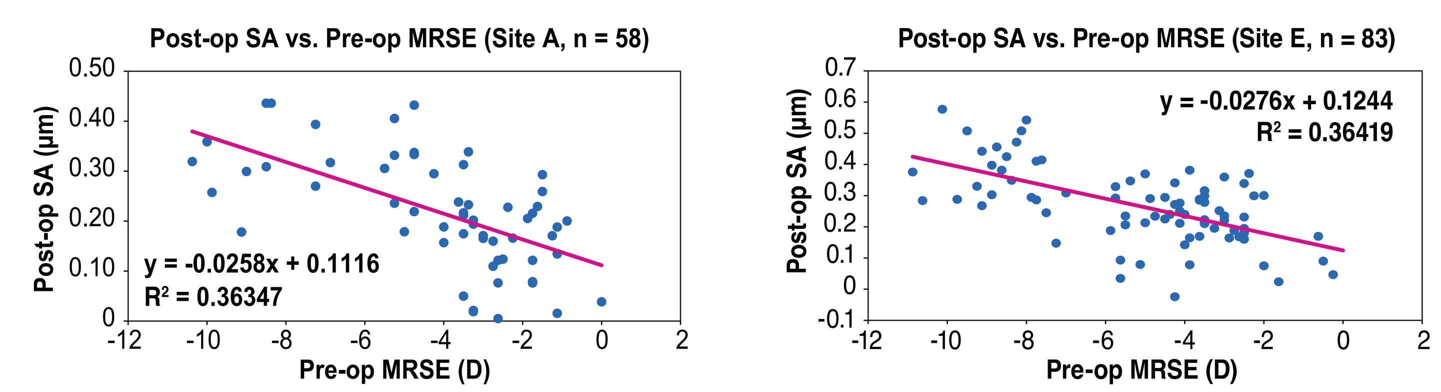


Figure 4. Scatter plots and the regression for the post-operative SA vs. pre-operative MRSE for site A (left) and E (right).

When similar analysis was conducted for surgeons, we again found an induction of positive SA, as shown in Fig. 5.

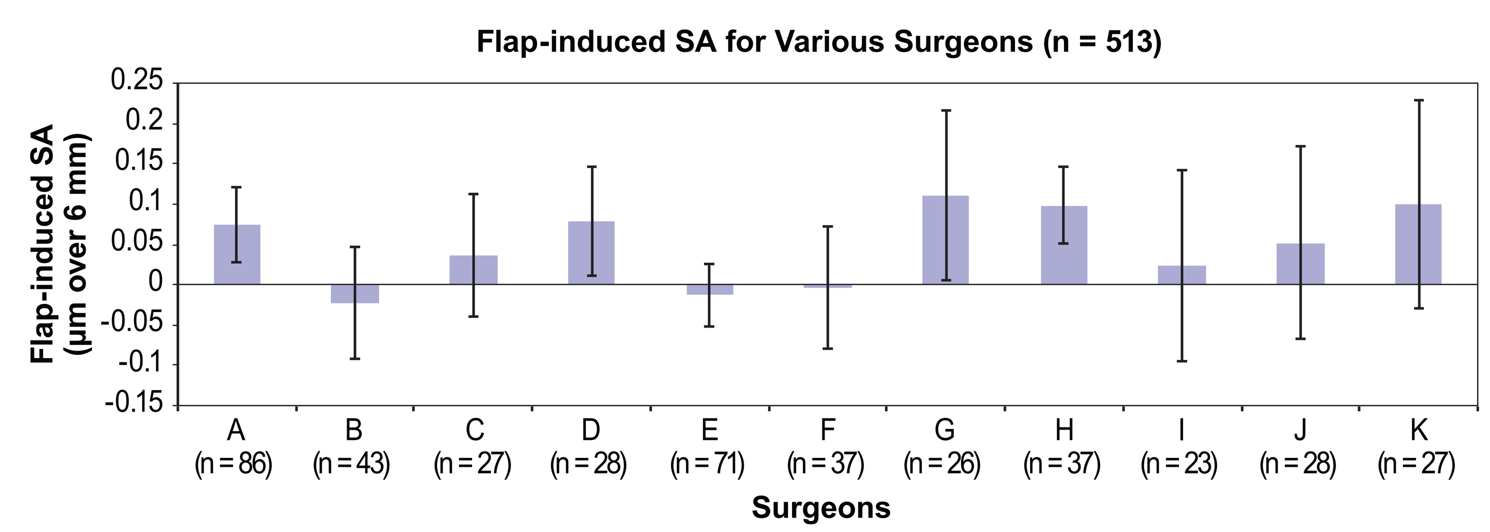
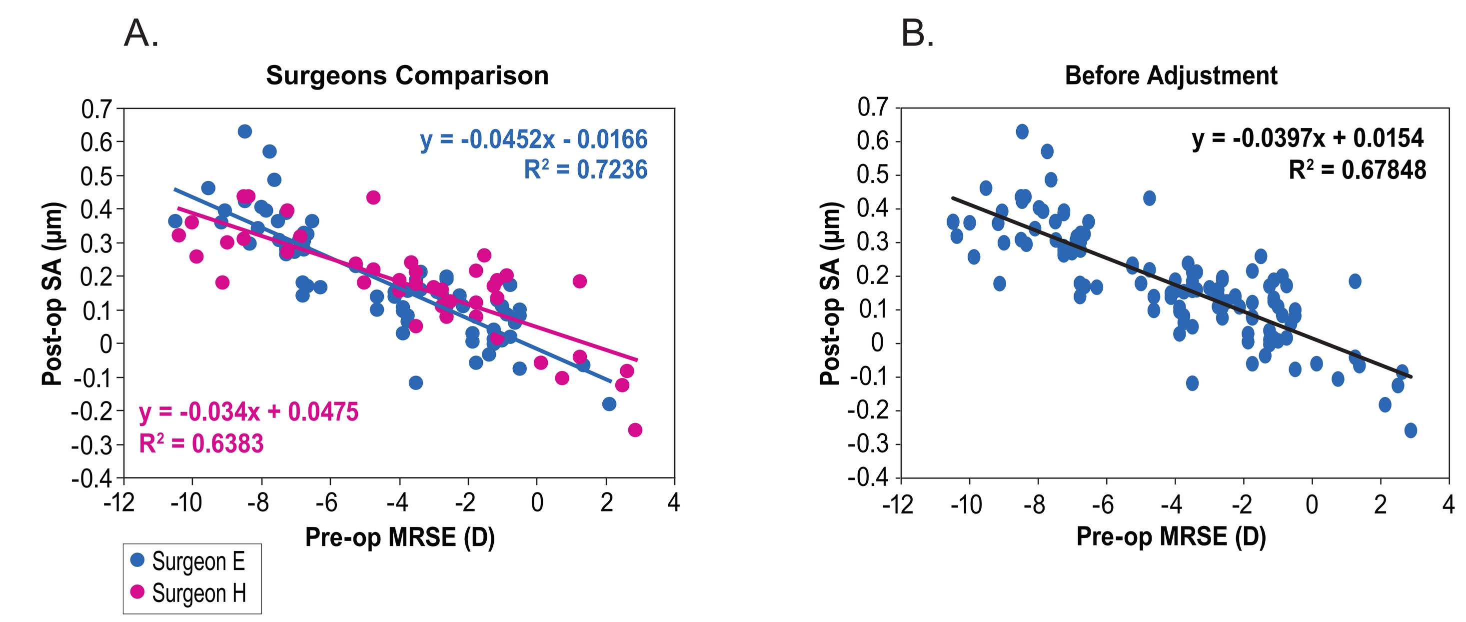


Figure 5. Regression intercept (flap-induced SA) from scatter plots between post-operative SA and pre-operative MRSE for various surgeons.

Figure 6 compares Surgeon E and Surgeon H to illustrate use of the SA_0 information. It is clear that after adjustment, the data points become tighter (with a higher R-Square).



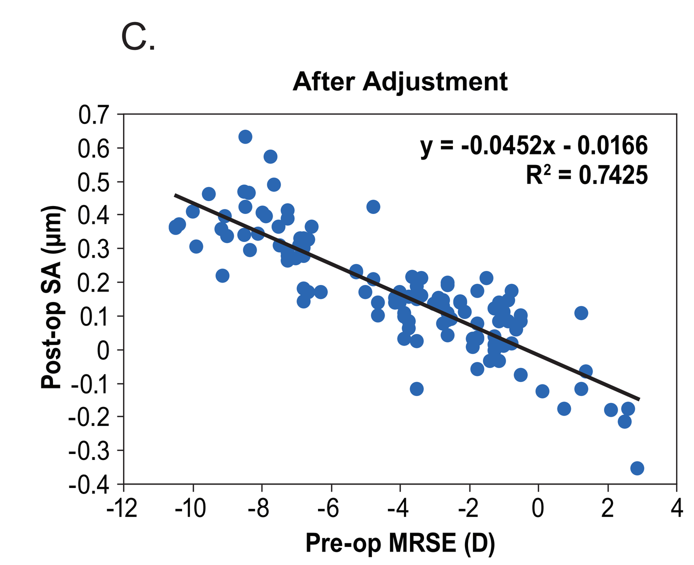


Figure 6. (A) Post-op SA vs. pre-op MRSE regression trend lines for Surgeons E and H; (B) scatter plot for the combined data set before SA_0 adjustment; (C) scatter plot for the combined data set after SA_0 adjustment.

Conclusions

Flap-induced aberrations of LASIK treatments may substantially contribute to surgery outcome. The magnitude of the flap-induced SA may vary because of differences in surgeon techniques, sites, or instruments. An estimate should be made for each individual situation; and then data for different surgeons may be combined for subsequent analysis and adjustments.

References

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2. Durrie D, Kezirian G, Femtosecond laser versus mechanical keratome flaps in wavefront-guided *in situ* keratomileusis: prospective contralateral eye study. J Cataract Refract Surg, 2005; 31:120–126

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