not reliably and reproducibly differentiate between these 2 questions. We would ask the authors about the difference in response to these 2 questions and how this impacted their analysis.

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References


Dear Editor:

Chan and Manche\(^1\) discuss the correlation between pupil size and visual disturbances after keratorefractive surgery (KRS). They provide us with a wealth of analyses on visual disturbances and discomforts and the postoperative course. However, they do not mention a fundamental factor: the zone that is photoablated.

In KRS we intend to reshape the cornea in an area named “optical zone” (OZ), and we include it as an integral parameter of the treatment plan. However, this “nominal” OZ is not the only determinant of “effective” OZ (EOZ). Laser decentration, pupil eccentricity, ablation depth and diameter, and ablation profile, as well as the amount of corneal reshaping after photoablation, are among the factors that determine the EOZ. Chan and Manche\(^1\) cases are in the range of mild to moderate myopia with mild astigmatism, which translate to relatively bigger EOZs compared with eyes with higher degrees of refractive error.\(^2\) However, the EOZ should also be accessed directly in topographic maps and in longer-term follow ups; we know that larger treated zones are more stable and the stability of the corneal reshaping is just as important as the intended OZ.\(^3\)

According to Chan and Manche,\(^1\) wavefront guided technology may explain the lack of a significant role of the pupil size on quality of vision; but their hypothesis is too general. It should be further specified which feature of this modality may be working: a relatively larger EOZ, milder higher order aberration (HOA) induction, or better centration and eye tracking. In their next paragraph, they refer to the “strong correlation between the level of the attempted correction and visual symptoms.” This relates to the concept that in deeper ablations, both of the EOZ\(^1\) and the functional optical zone (FOZ)\(^4\) are smaller and the refractive outcome is less precise; in addition, the induced HOAs would be worse too.

We know that the size of the entrance pupil (EP) depends on the corneal power and the anterior chamber depth; therefore, the deeper and steeper the cornea, the larger would be the EP.\(^5\) Moreover, according to Freedman’s calculations,\(^5\) for an EP of up to 5.5 mm, an EOZ of at least the size of the EP for scotopic lighting conditions would theoretically result in minimal visual disturbances. For small- and medium-sized pupils we can be more confident that the EOZ would not be smaller than the EP; but for larger pupils, this may become an issue. So, hypothetically, if you have cases with the EOZ larger than the EP, you should not expect a visual disturbance to be related to the EOZ. Simultaneous wavefront analysis and contrast sensitivity function (CSF) evaluation, and their evolution and correlation with visual symptoms in the postoperative period should further elucidate the pupil size role. Entrance pupil and EOZ interaction yields a FOZ which is to be used in such analyses and surgical planning. Furthermore, the role of the Stiles-Crawford effect on reducing HOAs in larger pupil sizes should also be mentioned.

An interesting observation was that they found medium-sized pupils to be advantageous. This can be explained by the fact that the best theoretical vision is limited by diffraction in smaller pupil sizes and by aberrations in larger pupil sizes.

Another point to bear in mind is that the phenomenon of neuroadaptation can also influence the subjective postoperative visual experience of the patients, and an improvement in CSF during follow-up visits has been well documented\(^6\); but this process might be hampered when there is significant residual error. This means that we should evaluate the pupil size role in a homogeneous cohort of eyes with negligible residual spherocylindrical error.

Simulation is an extremely versatile tool for this purpose. The OZ, EP, and other factors can be modified and the outcome can be analyzed through the point-spread function. In our belief, it is still premature to conclude that the pupil size has little effect on the KRS outcome, as many factors like the EP, FOZ, and EOZ, the residual refractive error, and the individual’s neural adaptation potentials may confound the outcome.

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References

Author reply

Dear Editor:

We would like to thank Soleimani et al for their comments regarding our manuscript. They noted that we did not define the level of illumination under which our pupil size measurements were performed. We acknowledge that this information is critical to the study and should have been included in the original manuscript. I have previously detailed this information in another letter to the editor. The measurements were made in the following manner: patients were dark adapted for 2 minutes at 1 lux ambient light as measured by a calibrated luxmeter. All pupil size measurements were performed before having any bleaching tests (i.e., slit lamp examination, computerized videokeratography, etc.). Accommodation and convergence were controlled by having patients fixate on a distance target 15 feet away. All measurements were made by a single experienced study technician in a calibrated testing lane using Early Treatment of Diabetic Retinopathy Study visual acuity charts.

Soleimani et al point out the fact that 2 methods of flap creation were used in the study (femtosecond laser and mechanical keratome) and that a subanalysis should have been performed. As part of our initial analysis, we looked at the effect of flap creation technique on our results. The subanalysis of our data showed no difference in the outcomes that we reported in our published study between the eyes treated with a mechanical keratome compared with those treated with a femtosecond laser. This finding is supported by our previous work comparing clinical outcomes in subjects undergoing wavefront-guided LASIK using a mechanical keratome in 1 eye and a femtosecond laser in their fellow eye. In that study, we demonstrated that there were no significant differences in any clinical outcomes including higher order aberrations at 1 year.

Soleimani et al question the rationale for including information regarding dry eye and dry eye severity in the manuscript. In an effort to be complete, we elected to include the data regarding dry eye and dry eye severity because these questions were part of our pre- and postoperative questionnaire. We have addressed the issue of differences in dry eye and dry eye severity between mechanical keratomes and femtosecond lasers in a separate manuscript.

We would also like to thank Mohammadi et al for their comments regarding our manuscript. The authors point out that we did not provide any information regarding the programmed ablation zone in our study. We agree that this data is important and should have been detailed in the manuscript. All eyes were treated using the standard default 6.5-mm programmed optical zone treatment with a 9-mm peripheral blend zone.

We agree with Mohammadi et al that the lack of any correlation between preoperative pupil size and postoperative visual symptoms is multifactorial and not solely related to the use of wavefront-guided technology. Each of the factors that Mohammadi et al detailed (programmed optical zones, milder induction of higher order aberrations, better centration, and eye tracking) could independently influence postoperative visual symptoms. Further studies looking at these variables independently would be very useful but are outside of the scope of our manuscript.

Mohammadi et al refer to our manuscript where we state that, “A number of previous studies found a strong correlation between the level of attempted correction and visual symptoms, particularly glare, after previous refractive surgery.” We want to emphasize that we were referring to previous studies and not our study. In our study, we found no correlation between the level of attempted correction and any measured postoperative visual symptoms.

Lastly, we agree that neuroadaptation and the Stiles-Crawford effect may play an important role in influencing visual symptoms following keratorefractive surgery. Many published studies have found no correlation between preoperative pupil size and postoperative visual symptoms. In many of the earlier studies, relatively small optical treatment zone sizes were used. In one of the earliest studies looking at the relationship between postoperative visual symptoms and preoperative pupil size, Haw and Manche used a programmed elliptical treatment zone of 6.0 by 5.0 mm without any blend zones to treat compound myopic astigmatism with photorefractive keratectomy. In another early study, Schallhorn et al used an elliptical ablation in a subset of patients undergoing LASIK with compound myopic astigmatism. In some cases, the programmed elliptical ablation zones were as small as 6.0 by 4.5 mm with no blend zone. In both studies the preoperative pupil size had no effect on postoperative symptoms at 24 months and 6 months respectively. If the size of the programmed optical zone, effective optical zone, and functional optical zone were of primary importance, simple geometric optics would dictate that patients with significant mismatches between their pupil size and the programmed optical zone would necessarily have visual symptoms. Since this relationship has not been shown to exist, other factors need to be considered.

We appreciate the opportunity to clarify several aspects of our study and stimulate discussion in this important area of research. We look forward to additional studies to help us gain a better understanding of the etiology of postoperative visual symptoms after keratorefractive surgery.

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References