Topographic, Tomographic, and Aberrometric Characteristics of Post-LASIK Ectasia

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ABSTRACT

Purpose. To report the refractive, topographic, tomographic, and aberrometric characteristics of post-LASIK ectasia; to compare these characteristics with normal post-LASIK controls; and to propose a comprehensive system to grade the severity of post-LASIK ectasia.

Methods. The refraction, corrected distance visual acuity (CDVA), magnitude, and location of the steepest and thinnest point on the cornea, the highest anterior and posterior surface elevation, the radius of best fit sphere, corneal asphericity, and corneal aberrations were measured in 50 eyes of 29 patients with post-LASIK ectasia. These were compared with corresponding parameters in 50 eyes that did not develop ectasia for more than 1 year after LASIK. A logistic regression analysis was used to create a scoring system to grade the severity.

Results. Eyes with post-LASIK ectasia had significantly higher myopia with astigmatism and a lower CDVA than control eyes. Mean topographic toricity was 3.4 ± 1.9D, mean keratometry at the steepest point was 55.32 ± 6.63D, mean highest posterior elevation was 69.72 ± 3 μm, and mean coma was −2.06 ± 1.2 μm. All these parameters were significantly higher than corresponding values in the control group (p < 0.001 in all). Spherical aberration was more negative and the change in asphericity indicated significantly greater prolate shape of the cornea in eyes with post-LASIK ectasia compared to controls. Five parameters, namely, CDVA, spherical equivalent, highest posterior corneal elevation, spherical aberration, and corneal asphericity, were identified as significant predictors of post-LASIK ectasia and used to create a scoring system.

Conclusion. Post-LASIK ectasia is characterized by significant changes in refraction, topography, tomography, and aberrometry. The proposed scoring system may be useful in diagnosing, grading, and monitoring post-LASIK ectasia.

Keywords: post-LASIK ectasia, scoring system

Corneal ectasia after refractive surgery is referred to variously as iatrogenic keratectasia (when it occurs after any form of refractive surgery) or post-LASIK ectasia (when it follows LASIK). It is characterized by a progressive corneal steepening associated with a decrease in the uncorrected and/or best corrected visual acuity after refractive surgery. First reported by Seiler et al.1 in 1998, it is recognized as a serious complication of refractive surgery, one that can be visually debilitating and difficult to treat.

Several preoperative and intraoperative risk factors have been identified.2 Unrecognized pre-existing keratoconus, forme fruste keratoconus, pellucid marginal degeneration, or the biomechanical weakening of the cornea by the refractive procedure itself are believed to be the most common risk factors for this condition. An Ectasia Risk Score System (ERSS) has been designed by Randleman et al.2 to effectively screen candidates for refractive surgery and takes into account the age of the patient, the manifest refraction, the corneal thickness, the preoperative topography pattern, and the residual stromal bed after ablation. Tabbara et al.3 presented a scale based on Orbscan measurements to assess the risk of developing ectasia after LASIK. Kachikian et al.4 used posterior elevation data and Ambrosio et al.5 introduced corneal thickness spatial profiles to increase the sensitivity and specificity of detection of subclinical keratoconus—the major risk factor for iatrogenic keratectasia. Despite stringent preoperative screening, several cases of iatrogenic keratectasia have been reported with no clear etiological explanation.6

Visual morbidity associated with iatrogenic keratectasia could be distressing to the patient, and the progressive biomechanical
failure may cause the ectasia to be severe enough to require corneal transplantation. Early detection is thus important, but would need a complete clinical characterization and identification of parameters that could be predictive of the incipient stage of this condition.

A retrospective analysis of published case reports and a comparison with a group of successful LASIK patients were done by Twa et al.\(^7\) to define the clinical characteristics of post-LASIK ectasia. Some important clinical criteria were proposed, but were predominantly refractive in nature. Spadea et al.\(^8\) reported the incidence of post-LASIK ectasia from among a large dataset of patients operated on by the same surgeon, but only focused on the Randleman ERSS which was applied retrospectively. Brenner et al.\(^9\) worked out a grading system based on visual limitation that could be used to plan treatment and predict outcomes.

The aims of our study were (1) to report the refractive, topographic, tomographic, and aberrometric characteristics of post-LASIK ectasia; (2) to compare these characteristics with those in normal post-LASIK controls who did not develop ectasia; and (3) to grade the severity of post-LASIK ectasia based on measurable parameters. To the best of our knowledge, there is no other study, published in peer-reviewed literature, which has met these objectives. Recognizing these changes may enable the clinician to arrive at a definitive and early diagnosis and facilitate prompt management. Grading the severity of the condition may enable an algorithmic approach to its management.

PATIENTS AND METHODS

This was a retrospective case-control study of patients diagnosed with post-LASIK keratectasia at a tertiary eye care center. Except for one patient who had her LASIK performed at our center, all other patients had their LASIK done elsewhere and either reported to us or were referred to us with visual symptoms and/or recurrence of refractive errors. Because Randleman et al.\(^2\) have shown that most cases of ectasia become apparent within the first 6 months after surgery, we followed the criteria used by other authors\(^7,10\) in choosing patients who had undergone an uneventful LASIK procedure at our center and had not developed ectasia over at least 1 year to serve as controls. This study adhered to the tenets of the Declaration of Helsinki.

A post-LASIK ectasia was suspected when a patient reported a drop in uncorrected or best corrected vision or an increase in visual symptoms like haloes, glare, ghost images, etc. The diagnosis of post-LASIK ectasia was confirmed if there was a refractive change of 2D or more of spherical equivalent, a topographic corneal steepening or toricity of 1.50D or more, or if there were obvious signs of ectasia (unusual corneal thinning, Vogt’s striae, Fleischer ring, Munson’s sign) on slit-lamp examination. Patients were included in the control group if they had undergone uncomplicated LASIK and showed stable refraction, topography, and pachymetry for at least 1 year. Non-cycloplegic retinoscopy was attempted in all cases. If the reflex was unreliable, autorefraction (Auto Refractor Keratometer; Topcon Medical System Inc, Oakland, NJ) was performed, followed by a subjective acceptance. Visual acuity was measured using the early treatment diabetic retinopathy study (ETDRS) chart and converted to the logarithm of the minimum angle of resolution (logMAR) format. Corneal topography was recorded with the TMS-4 (Tomey Corporation, Nagoya, Japan) and corneal tomography with the Pentacam HR (Oculus Optikgeraete GmbH, Wetzlar, Germany).

A minimum of three successive maps were recorded for each eye with each instrument. The one with the best centration and least extrapolated data was chosen among them. If all three maps appeared well centered and reliable, one of them was chosen at random for the study. If none was reliable, the eye was excluded from the study.

Topography Analysis

The Simulated Keratometry values (Sim K1 and Sim K2), the topographic cylinder, and the topographic indices of regularity and asymmetry (SRI and SAI) were noted from the axial map of topography. The location and power of the steepest point on the corneal surface was determined from the raw data of the curvature measurements, using the VOL-CT software (Sarver and Associates, Inc., IL).

Corneal Aberrations

The Zernike coefficients of the corneal aberrations up to the sixth order and the root mean square of the total higher order aberrations (RMSh) were derived from the raw data of the topography, using the VOL-CT software. Measurements were recorded for an optical zone of 6.5 mm.

Tomography Analysis

The highest anterior and posterior elevation (HAE and HPE) and their respective location were noted from the Pentacam manually, using the cursor in the central 4 mm zone. The location and pachymetry of the thinnest point on the cornea was also noted. The radius of the best fit sphere (BFS) at 8 mm diameter both for the anterior and the posterior corneal surfaces and the corneal asphericity (Q) values of the anterior and posterior corneal surfaces at 6 mm optical zone were recorded.

Statistical Analysis

Statistical analyses were performed using statistical software (SPSS for Windows version 13.0; SPSS Science, Chicago, IL). The results were expressed as mean ± standard deviation if the variables were continuous and as percentage if the variables were categorical. The Student t-test for comparing continuous variable, paired t-test for comparing pre- and post-treatment continuous variables, and the chi-square test to compare proportions among groups and ANOVA for comparing multiple groups were used. We checked for correlation between the eyes in the subjects with bilateral post-LASIK ectasia and found there was no significant correlation using the following variables: Sim K1 (r = −0.069, p = 0.78), Sim K2 (r = −0.007, p = 0.98), steepest K (r = −0.153, p = 0.56), distance of steepest K from the corneal center (r = 0.412, p = 0.10), HPE (r = 0.254, p = 0.31), HAE (r = 0.09, p = 0.724), and SRI (r = −0.285, p = 0.252). Therefore, both eyes of the patient with bilateral post-LASIK ectasia were included in our study for final analysis. Both univariate and multivariate logistic regression analyses were performed to study the
effect of various risk factors using post-LASIK ectasia as a dependent variable. From the univariate analysis, variables with p-values of 0.05 or less and those that were already established as risk factors were included in the multivariate logistic regression analysis to derive the parsimonious model. A p-value of ≤0.05 was considered significant.

RESULTS
Fifty-five eyes of 32 patients seen in the refractive surgery clinic of a tertiary eye care hospital between 2005 and 2013 were diagnosed with post-LASIK ectasia. Of the 32 patients, 23 had bilateral ectasia and 9 patients had unilateral ectasia. Of the 55 eyes with post-LASIK ectasia, 5 eyes had advanced ectasia, and because their topography or tomography maps were unreliable, they were not included in the analysis. This study thus presents the results of the analysis of 50 eyes for which the data was found reliable. The male/female ratio was 19:13. The mean age was 30.1 ± 4.9 (range 23–44).

Fifty eyes of 50 patients who had undergone uneventful LASIK for correction of myopia and who had not developed ectasia for at least 1 year after LASIK formed the control group. The male/female ratio was 26:24 and the mean age was 23.9 ± 4.0 (range 18–40).

Refractive and Visual Results
Eyes with post-LASIK ectasia had significantly higher myopia with astigmatism than controls. The mean spherical equivalent was −5.10 ± 4.38D (range 0.75 to −20) in the post-LASIK ectasia group and −0.04 ± 0.14 (range 0 to −0.75D) in the control group. The corrected distance visual acuity was significantly less in the post-LASIK ectasia group (mean corrected distance visual acuity in logMAR 0.26 ± 0.27) than in the control group (mean corrected distance visual acuity in logMAR −0.03 ± 0.08; p ≤ 0.001) (Fig. 1A, B).

Topographic Analysis
Table 1 shows the comparison of parameters measured by corneal topography between cases and controls. The mean corneal topographic toricity was 3.4 ± 1.9D in the post-LASIK ectasia group and 0.76 ± 0.33D in the control group, the difference being statistically significant (p < 0.001). The mean value of the steepest point on the cornea was 55.32 ± 6.63D, located 1.33 ± 0.84 mm from the corneal center in the post-LASIK ectasia group, and 43.58 ± 1.26D, located 3.55 ± 1.06 mm from the corneal center in the control group. These differences in both magnitude and location of the steepest point between the two groups were statistically significant (p < 0.001). The topographic indices SRI (surface regularity index) and SAI (surface asymmetry index) were significantly higher in the post-LASIK ectasia group than in the control group.

Tomographic Analysis
Table 2 shows the comparison of parameters measured by the Pentacam. The BFS both for the anterior and posterior corneal
Corneal Aberrations

Point on the cornea, as measured by the Pentacam, was 402.14 different between both groups. The mean thickness of the thinnest of both anterior and posterior corneal surfaces were significantly compared to controls. The highest elevation and corneal asphericity surfaces had a significantly smaller radius of curvature in cases.

Distance of steepest K

Sim K2 (D) 47.03

T

T

Parameter
Sim K1 (D)
Sim K2 (D)
Steepest K (D)
Distance of steepest K
from corneal center (mm)
SRI
SAI

50.59 ± 5.87
47.03 ± 5.25
55.32 ± 6.63
1.33 ± 0.84
1.18 ± 0.82
2.32 ± 1.26

39.54 ± 2.6
38.77 ± 2.58
43.58 ± 1.26
3.55 ± 1.06
0.23 ± 0.17
0.39 ± 0.22

<0.001
<0.001
<0.001
<0.001
<0.001
<0.001

p < 0.05 was considered statistically significant.

Sim K1 (D), simulated keratometry at steeper meridian (in diopters); Sim K2 (D), simulated keratometry at flatter meridian (in diopters); SRI, surface regularity index; SAI, surface asymmetry index.

Corneal Aberrations

Fig. 3A and B shows the mean Zernike coefficient of the third and fourth radial order and the mean root mean square of the entire range of each parameter was then equally divided into four categories and named as normal, mild, moderate, and severe, respectively, as shown in Table 3. Because coma is known to typically result from a decentered ablation, it would be difficult to use it to distinguish decentered ablation from post-LASIK ectasia. Hence, it was not used in the grading system.

Based on this grading system, the total score was calculated for each eye (Table 4) and the severity of the post-LASIK ectasia was classified as 0 “normal” (score <5), I “mild post-LASIK ectasia” (score 6–10), II “moderate post-LASIK ectasia” (score 11–15), and III “severe post-LASIK ectasia” (score >15).

ANOVA was performed between the groups across each parameter, which showed a significant difference between the groups (p < 0.001).

DISCUSSION

Although iatrogenic keratectasia is now a well-recognized complication of refractive surgery, its etiology remains inadequately understood and its clinical profile incompletely characterized.

Like keratoconus, post-LASIK ectasia manifests as a progressive corneal steepening and thinning, resulting in irregular astigmatism, degradation in quality of vision, and debilitating optical symptoms like glare and halos.

Unlike keratoconus, there are no validated standard criteria for detecting post-LASIK ectasia in its subclinical stage or even for diagnosing it in its manifest form. Randleman et al. 2 defined post-LASIK ectasia as an inferior topographic steepening of 5D or more compared with immediate postoperative appearance, loss of two or more lines of Snellen acuity, and a change in manifest refraction of 2D of either spherical or cylindrical power. Based on published case reports of post-LASIK ectasia, Twa et al. 7 recommended three or four positive findings from among nine clinical criteria which included refractive, pachymetric, and topographic data that could be used to represent the clinical characteristics of post-LASIK ectasia, even if insufficient to make a diagnosis. Pinero et al. 11 included “internal astigmatism” as an important criterion to detect early signs of ectasia after LASIK. Although the authors summarized the findings of cases reported until then in peer-reviewed literature, they neither included measurements of the posterior corneal surface nor of corneal surface aberrometry—both of which are now accepted clinical tools for evaluating early ectasia and ocular optical quality. This study uses multiple parameters that could comprehensively characterize post-LASIK ectasia.

### TABLE 1.

Summary of comparison of parameters measured by corneal topography among cases of post-LASIK ectasia and controls

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Post-LASIK ectasia N = 50</th>
<th>Control N = 50</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sim K1 (D)</td>
<td>50.59 ± 5.87</td>
<td>39.54 ± 2.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sim K2 (D)</td>
<td>47.03 ± 5.25</td>
<td>38.77 ± 2.58</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Steepest K (D)</td>
<td>55.32 ± 6.63</td>
<td>43.58 ± 1.26</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Distance of steepest K from corneal center (mm)</td>
<td>1.33 ± 0.84</td>
<td>3.55 ± 1.06</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>SRI</td>
<td>1.18 ± 0.82</td>
<td>0.23 ± 0.17</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>SAI</td>
<td>2.32 ± 1.26</td>
<td>0.39 ± 0.22</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

p < 0.05 was considered statistically significant.

### TABLE 2.

Summary of comparison of parameters measured by Scheimpflug imaging among cases of post-LASIK ectasia and controls

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Post-LASIK ectasia N = 50</th>
<th>Control N = 50</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ant BFS (mm)</td>
<td>7.43 ± 0.36</td>
<td>8.32 ± 0.39</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Post BFS (mm)</td>
<td>5.88 ± 0.35</td>
<td>6.32 ± 0.23</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>HAE (μm)</td>
<td>28.9 ± 13.93</td>
<td>11.8 ± 5.75</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>HPE (μm)</td>
<td>69.72 ± 3.0</td>
<td>12.12 ± 4.01</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Q</td>
<td>−0.61 ± 0.83</td>
<td>1.19 ± 1.05</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TP (μm)</td>
<td>402.14 ± 61.34</td>
<td>455.01 ± 56.77</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Ant BFS, radius of best fit sphere of anterior corneal surface (mm); Post BFS, radius of best fit sphere of posterior corneal surface (mm); HAE, highest elevation of anterior corneal surface (μm); HPE, highest elevation of posterior corneal surface (μm); Q, corneal asphericity of anterior corneal surface at 6 mm optical zone; TP, thickness of cornea at the thinnest point (μm).
FIGURE 2.
Location of the steepest point, highest posterior corneal elevation, and the thinnest point in the post-LASIK ectasia group (cases) and control group after and before the LASIK procedure. Both axes represent distance from the corneal center in millimeters.

FIGURE 3.
A, Mean Zernike coefficient of the third and fourth radial order of corneal aberrations among cases and controls. Error bars indicate 1 standard error of mean. p-value is shown above each coefficient comparing cases with controls. B, Mean root mean square (RMS) of second, third, and fourth radial order and of all corneal higher order aberrations (RMS-h) among cases and controls. Error bars indicate 1 standard error of mean.
TABLE 3.
Criteria for the proposed grading system for post-LASIK ectasia

<table>
<thead>
<tr>
<th>Grade</th>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>CDVA</td>
<td>≤0.18</td>
<td>0.19−0.48</td>
<td>0.49−0.78</td>
<td>&gt;0.78</td>
</tr>
<tr>
<td>SE</td>
<td>+1 to −1</td>
<td>−1.1 to −5</td>
<td>−5.1 to −10</td>
<td>&lt;−10</td>
</tr>
<tr>
<td>HPE</td>
<td>≤25</td>
<td>26−50</td>
<td>51−75</td>
<td>&gt;75</td>
</tr>
<tr>
<td>Z₄⁰</td>
<td>≥0</td>
<td>&lt;0 to ≥−0.5</td>
<td>&lt;−0.5 to ≥−1</td>
<td>&lt;−1</td>
</tr>
<tr>
<td>Q</td>
<td>≥0</td>
<td>&lt;0 to ≥−1</td>
<td>&lt;−1 to ≥−2</td>
<td>&lt;−2</td>
</tr>
</tbody>
</table>

CDVA, corrected distance visual acuity; SE, spherical equivalent; HPE, highest posterior elevation; Z₄⁰, Zernike coefficient for spherical aberration; Q, corneal asphericity.

Studies with the Pentacam have shown no significant changes in the posterior surface of the cornea after refractive surgery in normal myopes.12−14 Because mild degrees of post-LASIK ectasia may be better detected at the level of the posterior corneal surface,15 we believe that studying the posterior corneal surface in post-LASIK ectasia with the Pentacam would accurately characterize those changes and allow a three-dimensional tomographic reconstruction of the cornea, as advocated by Belin and Ambrosio.16

Our observations confirm that changes in posterior corneal elevation are significant and could be used as one of the criteria to detect and grade the severity of post-LASIK ectasia. We must, however, bear in mind that measurements of the posterior corneal surface are very instrument-dependent and those used in the analysis pertain only to the Pentacam HR.

Our study, like many others,7,9,11 suggests that refractive and biometric parameters are useful to distinguish the clinical characteristics of post-LASIK ectasia from eyes which have enjoyed a successful surgical outcome.7 A “regression” of myopia, particularly if it is accompanied by increased corneal toricity, must be viewed with suspicion. Such eyes must be scrutinized for other features of post-LASIK ectasia and watched for at least 6 months for refractive and biometric stability before any laser refractive enhancement procedure is contemplated. Injudicious retreatments could in fact further weaken the already weak cornea and accelerate the deterioration. Multiple enhancements have been correlated with ectasia,17 although they are also more frequently performed in these cases. Even though we could not rate our patients on the ERSS system, some important inferences could be drawn. Pachymetric measurements and changes at one point on the cornea alone do not reflect the biomechanical strength of the cornea. As has been shown the minimum residual stromal bed could vary from one cornea to another,18 that a thin cornea alone is not an isolated risk factor,19 and a spatial pachymetric profile of the cornea, rather than a single data point, is more reflective of risk for ectasia.20 All the cases of post-LASIK ectasia in our study, including the ones with a thinnest pachymetry of >400 μm, showed an abnormal corneal thickness spatial profile curve.

Irregular corneal toricity with central and/or inferior steepening is the classical topographic description of post-LASIK ectasia. The location of the steepest point on the cornea before and after LASIK among the control group and in the post-LASIK ectasia group (Fig. 2) suggests an interesting trend. The steepest point on the cornea tends to return towards the center in the post-LASIK ectasia group. This may be a useful indicator of early ectasia. Faraj et al.21 suggested that when post-LASIK ectasia occurs in a normal cornea, it presents as a central steepening, whereas corneas with forme fruste keratoconus are more likely to develop inferior ectasia. All the cases in our study showed a central steepening.

Corneal asphericity typically becomes more oblate after conventional myopic LASIK correction. However, in post-LASIK ectasia, there is a reversal of this change towards greater prolateness.

The increased central corneal steepening, the corneal asphericity, and spherical aberration increasing in the negative direction all point towards the corneal shape changing towards greater prolateness. Buhren et al.10 reported horizontal coma to be the predominant aberration among the five patients with post-LASIK ectasia that they reported, signifying a horizontal asymmetry in their dataset. Whether these differences reflect pre-existing variations in topography that get accentuated when post-LASIK ectasia sets in or etiologically different subtypes of post-LASIK ectasia is a subject for future investigation.

The lack of pre-LASIK details of topography, tomography, and aberrometry and intraoperative details like flap thickness, ablation depth, etc. are some of the important limitations of this study.

Access to such information and a larger dataset would have helped us.

TABLE 4.
Stratification of severity of post-LASIK ectasia among cases and controls in this study based on the proposed grading system

<table>
<thead>
<tr>
<th>Grade</th>
<th>Normal N = 46</th>
<th>Mild N = 24</th>
<th>Moderate N = 23</th>
<th>Severe N = 7</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDVA</td>
<td>−0.046 ± 0.076</td>
<td>0.079 ± 0.096</td>
<td>0.310 ± 0.243</td>
<td>0.633 ± 0.228</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>SE</td>
<td>−0.04 ± 0.15</td>
<td>−1.75 ± 2.34</td>
<td>−6.80 ± 3.77</td>
<td>−8.12 ± 5.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>HPE</td>
<td>11.83 ± 3.43</td>
<td>45.45 ± 18.87</td>
<td>76.91 ± 25.86</td>
<td>98.28 ± 47.37</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Z₄⁰</td>
<td>0.594 ± 0.268</td>
<td>0.252 ± 0.378</td>
<td>−0.322 ± 0.452</td>
<td>−2.004 ± 0.986</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Q</td>
<td>1.19 ± 0.86</td>
<td>0.16 ± 1.15</td>
<td>−0.72 ± 0.54</td>
<td>−1.86 ± 0.77</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

CDVA, corrected distance visual acuity; SE, spherical equivalent; HPE, highest posterior elevation; Z₄⁰, Zernike coefficient for spherical aberration; Q, corneal asphericity.
determine if post-LASIK ectasia that follows a pre-op unrecognized subclinical KC manifests differently from a post-LASIK ectasia that follows an iatrogenic weakening of a normal cornea.

Our proposed grading system took five measurable parameters into account, which helped us to stratify the eyes in terms of severity of ectasia. The benefits of creating such a scoring system are as follows:

1. It proposes quantified criteria to diagnose a post-LASIK ectasia
2. It could be used to assess progression of post-LASIK ectasia, and
3. as treatment options for post-LASIK ectasia evolve, this scoring system may enable the formulation of a suitable decision tree to systematize the approach to treatment and evaluate its efficacy.

The inclusion of a group of “post-LASIK ectasia suspects” with a suitably long follow-up of this group would have validated the grading and scoring system proposed in this study. Including appropriate measures of the biomechanical properties of the cornea would have been ideal, considering that the disease is primarily the result of a biomechanical breakdown. Identifying such parameters and designing instruments that can measure them in a clinical setting is an exciting and evolving area of current research.

CONCLUSIONS

Post-LASIK ectasia is a visually debilitating disease characterized by several visual, refractive, topographic, tomographic, and aberrometric changes. Some important observations from our current study suggestive of the development of post-LASIK ectasia include:

1. An increase in myopia and/or astigmatism with a decrease in corrected distance visual acuity.
2. An increase in magnitude of the highest anterior and posterior corneal elevation.
3. A shift of the location of the steepest point on the anterior surface that of the highest elevation of the posterior surface towards the corneal center.
4. A reversal of the corneal asphericity towards greater prolateness.
5. An increase in negative spherical aberration and coma.

We propose a grading and scoring system that may facilitate early diagnosis and allow prompt and effective treatment.

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