ORIGINAL ARTICLE

Comparison of Ectasia versus Pseudoectasia using the Ectasia Risk Factor Score System

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ABSTRACT

Objectives. To evaluate and compare ectasia and pseudoectasia in post-myopic LASIK patients presenting with corneal topographic changes indicative of ectasia using the Ectasia Risk Factor Score System (ERFSS).

Methods. Single-center retrospective comparative case series of a consecutive chart review of cases in 18 years who underwent bilateral myopic-LASIK and showed topographic changes indicative of ectasia.

Results. Four patients were included. Group 1: pseudoectasia eyes, consisting of two patients with bilateral pseudoectasia, and Group 2: ectasia eyes, consisting of two patients with unilateral ectasia. The clinical course of the cases was discussed and compared based on the ERFSS parameters: topography pattern, residual stromal bed thickness, age, preop thinnest cornea, and pre-operative spherical equivalent (SE) manifest refraction (MR). Group 1 scored zero to low risk for developing ectasia while Group 2-eyes with ectasia scored moderate risk. The predictive value of the ERFSS was 1 in this study.

Conclusion. The ERFSS is a good measure in deciding the suited treatment plan for patient undergoing refractive procedure. Knowing the clinical course of ectasia and pseudoectasia is helpful in the therapeutic approach since pseudoectasia is reversible when identified and managed early as seen in this study.

Keywords: ectasia, pseudoectasia, ectasia risk factor score system

INTRODUCTION

Corneal ectasia is a feared complication of post-myopic laser-assisted in-situ keratomileusis (LASIK). This belonged to a group of corneal disorders characterized by progressive thinning, distortion, and anterior bulging of the cornea.[1] LASIK involves the manipulation of the corneal stroma to create a refractive change; it is one of the safest procedures to correct near-sightedness and has existed since the 1990s. However, LASIK is not without its risks. Among which is iatrogenic ectasia first reported in 1998 by Seilers et al.[2] Post-LASIK ectasia is characterized by progressive thinning, with steepening of the cornea along the inferior or central axis and an associated decrease in uncorrected and best-corrected distance visual acuity. This post-complication has an estimated incidence of 0.03-0.9 %.[3,4]

Although corneal ectasia is rare, it remains one of the major problems after laser in situ keratomileuses (LASIK).[5] Surgically transecting the Bowman's membrane and removing the corneal stroma compromises the biomechanical strength of the cornea. It is presumed that excessive removal of the

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stroma leaves the remaining stromal bed thickness malleable to stresses like intraocular pressure (IOP) rise.[5,6] Tensions due to increased intraocular pressure (IOP) in post-operative patients can lead to pseudoectasia, where patients can experience decreased vision. Corneal topography will show ectatic changes, such as anterior bulging of the posterior float, steep keratometric axis, and thin corneal pachymeter. However, pseudoectasia, if identified early, can be successfully reversed. Anti-glaucoma drugs can be used to reverse pseudoectasia. It is not a permanent condition and will not progress to full-fledged ectasia. The term "pseudo" refers to the temporary forward protrusion of the cornea caused by increased intraocular pressure.

Knowing the pre-operative risk factors for ectasia is necessary for its prevention. Reports of pseudoectasia occur in patients with no apparent risk factor.[5] Randleman's ectasia risk factor score system (ERFSS) was presented around 2008[7] and has aided clinicians in assessing whether the patient is at a low to high risk of developing ectasia. Randleman's ERFSS used the following parameters: topography pattern, residual stromal bed thickness, age, pre-operative thinnest cornea, and pre-operative spherical equivalent (SE) manifest refraction (MR).[5] The scoring method has been validated and is now being used globally. This study is not a revalidation, but rather a practical implementation of the aforementioned scoring methodology. To date, no Filipino refractive paper has issued any score applications. Randlemann's case-control study comprises 50 cases and 50 controls to validate the scoring system's use.* The approach in our paper is simply a case series, but we strongly propose that future investigations include larger subjects.[8] Due to the scarcity of these conditions, it is worthwhile to note the significant clinical parameters that differentiate the two states as they may contribute additional information to refractive planning and emphasize thorough pre-operative preparation.

Using the Ectasia risk factor assessment score, this study aims to evaluate and compare ectasia and pseudoectasia in post-LASIK patients presenting with corneal topographic changes indicative of ectasia.

METHODS

This is a single-center retrospective comparative case series of a consecutive chart review in 18 years of cases that underwent bilateral myopic-LASIK and showed topographic changes indicative of ectasia. The topography pattern, residual stromal bed thickness, age, pre-operative thinnest cornea, and pre-operative spherical equivalent (SE) manifest refraction (MR) of the two groups of eyes with ectasia and pseudoectasia were compared and analyzed. In this study, no eye was used as a case or a control. Ethics approval was obtained from the local ethics review board. The study was done in accordance with the World Medical Association's Declaration of Helsinki. All patients were fully informed of the nature and details of the procedure, including all risks and benefits. Written informed consent was secured from all patients before their refractive screening. Permission was sought from the Ethics Review Board.

Included in the study were consecutive chart cases of patients who qualified and underwent uneventful myopic LASIK surgery by a single surgeon using the Technolas 217z100 (Technolas Perfect Vision GmbH, München, Deutschland) excimer laser and were clinically observed to have topographic changes indicative of ectasia within the five years post-operation in at least one or both eyes. Included charts should have data on the following: complete refractive screening that included high-contrast uncorrected distance visual acuity (UDVA) and corrected distance visual acuity (CDVA), manifest refraction, corneal topography using the Orbscan (version 3.14, Bausch & Lomb, Rochester, NY, USA), undilated and dilated ultrasound pachymetry, Schirmer tests, intraocular pressure (IOP) by Goldmann applanation tonometry, slit lamp biomicroscopy, dilated fundus evaluation, and pre-operative planning that includes residual stromal bed thickness. Exclusion criteria were patients with incomplete chart data who had a history of intraoperative complications, eye trauma, and a history of ocular foreign body.

The Ehlers correction factor[8] (Ehlers CF) was used to adjust for post-operative LASIK Goldman applanation tonometry reading. This correction factor correlates corneal thickness and IOP to adjust for over and under estimation of IOP in post-LASIK patients. IOP pressures above 21 millimeter mercury (mmHg) are considered elevated.

Topographic Analysis

True ectatic topographic changes are defined as having all the following: corneal steepening on the keratometric map, both anterior and posterior float should show consistent steepening. As well as consistent thinning of the cornea in the pachymetry map. Pseudoectasia topographic changes were defined as anterior bulging of the posterior float, steep keratometric axis, and thin corneal pachymeter. One refractive specialist did all the corneal topography assessments.

Evaluation using the Ectasia Risk Factor Scoring System (ERFSS)

Relevant clinical data were plugged into the ERFSS (Table 1) and analyzed for post-LASIK ectasia risk. The difference between ectasia and pseudoectasia using the ERFSS was determined; characteristics that did not fall in the rubric will fall under the pseudoectasia category. The positive predictive value of ERFSS in predicting ectasia was computed. Risk categories based on cumulative points were as follows: 0-2 points = low risk; 3 points = moderate risk; 4 points = high risk.

Table 1. Randleman's Ectasia Risk Factor Scoring System (ERFSS)[7]

Score	0	1	2	3	4
Topography pattern	Normal/ symmetrical	Asymmetric bowtie		Inferior steepening/ skewed radial axis	Form fruste KC
Residual stromal bed thickness (um)	>300	280-299	260-279	240-259	<240
Age (years)	>30	26-29	22-25	18-21	
Preop Corneal Thickness (um)	>510		481-510	451-480	<450
Preop MRSE (D)	-8 or less	>-8 to -10	>-10 to -12	>-12 to -14	>-14

Table 2. Pre-operative Summary Findings of Cases in this Study

Patient	Age	Sex	Eye	Pre-Operative Manifest Refraction (SE) in Diopters (D)	Topography pattern	Ultrasonic pachymetry (um)	Orbscan II pachymetry (um)	GAT (mmHg)	RST (um)
Group 1									
A	34	F	R	-4.87	Asymmetric bow tie	548	522	16	290
			L	-4.87	Asymmetric bowtie	545	531	16	288
B	31	M	R	-6.5	Regular / symmetrical topography pattern	588	591	16	350
			L	-5.13	Regular / symmetrical topography pattern	593	599	17	387
Group 2									
C	33	M	L	-4.1	Asymmetric bowtie	534	505	10	253
D	28	M	R	-2.5	Inferior steepening/ skewed radial axis	548	523	14	253

RESULTS

Four patients were included in the study Patients A and B had bilateral pseudoectasia while patients C and D exhibited unilateral ectasia (Table 2).

The date of all the cases' pre-operative screening and myopic LASIK procedures occurred before the publication of the ERFSS.

Eyes with pseudoectasia

Patient A, a 34-year-old Filipino female, underwent uneventful bilateral LASIK surgery. Her pre-operative measurements showed a manifest refraction of -4.50 sphere -0.75 cylinder x 95°, spherical equivalent (SE) of -4.87D,right eye and -4.75 sphere -0.25 cylinder x 90°, SE of -4.87D left eye and ultrasonic pachymetry showed normal corneal thickness of 522 um on the right and 531 um on the left, with the estimated residual bed thickness calculated to be 290 um and 288 um on the right and left eye, respectively while the keratometry map showed a bilateral asymmetric bowtie pattern (Figure 1). At day one and week one post-operation check-up, UCVA was 20/20 on each eye and corneas were clear. However, at one-month check-up, the patient complained of eye heaviness on the left eye, with

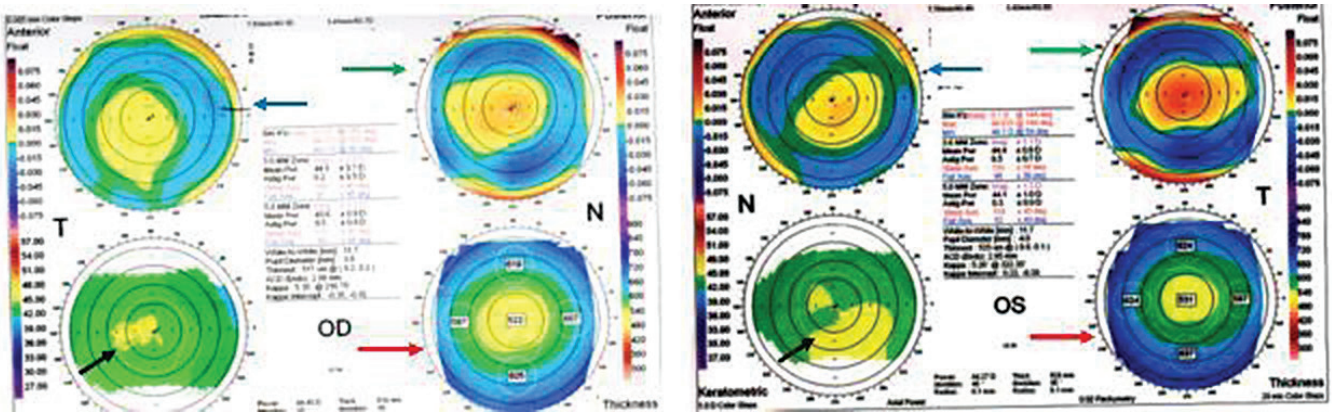

Figure 1. Topography showed a bilateral asymmetric bowtie pattern on the keratometry map. Black arrows on the keratometry map, showing an asymmetric bowtie via the yellow color on the right eye, and a larger asymmetric bowtie as indicated by the yellow color on the left eye. The anterior float *(blue arrow)*, posterior float *(green arrow)* and pachymetric or corneal thickness map *(red arrow)* were all normal.

UCVA worsened to 20/30 on the said eye with a manifest refraction of -0.75 sph = -0.50 cyl x 180°. The corneas and the flaps were clear while IOP was high at 24 mmHg and 25 mmHg on right and left eye, respectively using the Ehlers correction factor. Topography showed ectatic characteristics in both eyes (Figures 2A and 2B). Due to the high IOP, the post-operative steroid eye drops were discontinued and she was instead started on anti-hypertensive topical medications. One week later, the patient had no more eye complaints, uncorrected vision on both eyes returned to 20/20, IOP by using Ehlers correction factor was at 12 mmHg and 19 mmHg. Topography at one month and six months post-operation showed resumption of the normal corneal shape on both eyes (Figures 2A and 2B).

Patient B is a 31-year-old Filipino male, with the following pre-operative measurements: manifest refraction were: -6.00 sph = -1.00 cyl x 150°, SE -6.50D for the right eye and -4.75 sph = -0.75 cyl x 10°, SE -5.13D for the left eye. Ultrasonic

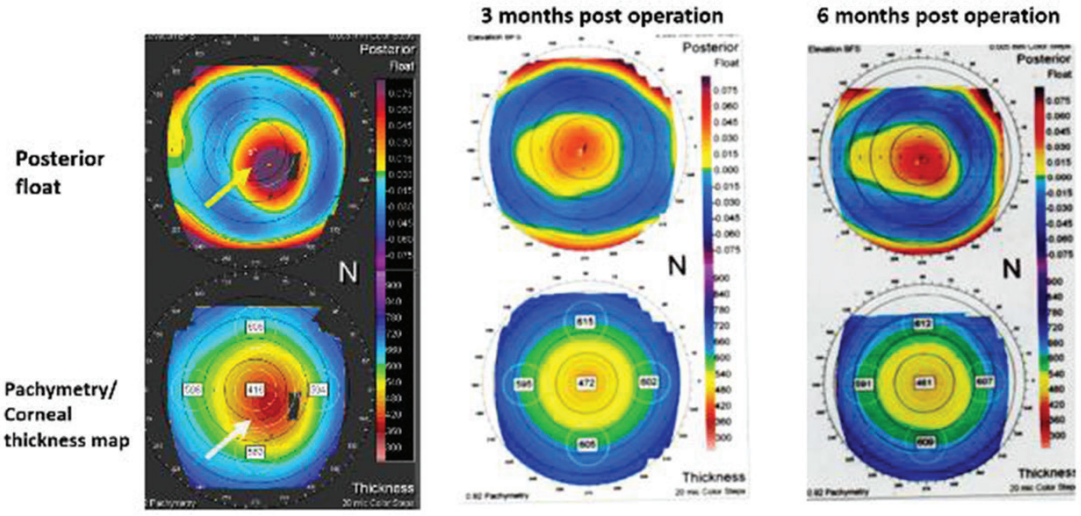

Figure 2A. ***Patient A Right Eye.*** Patient A one month post-operation showing signs of pseudoectasia *(yellow arrow central)*, thinning of the posterior float *(top left most)* and central thinning *(white arrow)* on the pachymetry map *(bottom left most)*. After IOP control, at 3 months resumption of normal posterior float shape *(top row middle figure)* with stability of normal posterior float shape at 6 months *(top rightmost)*. Pachymetry map showed resumption of normal thickness at 3 months *(middle bottom row)* with stability of thickness *(bottom rightmost)*.

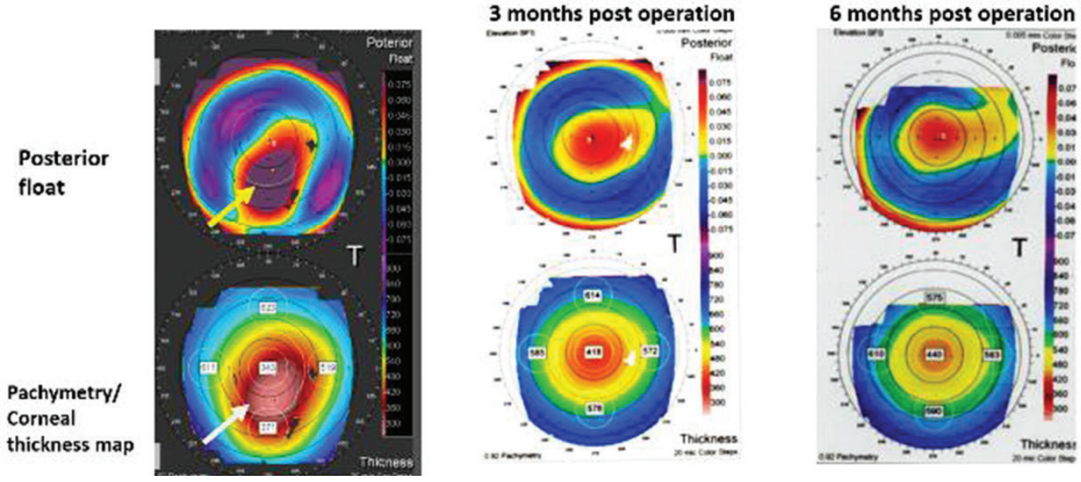

Figure 2B. ***Patient A Left Eye.*** Patient A one month post-operation showing signs of pseudoectasia *(yellow arrow central)*, thinning of the posterior float indicated by the very dark-warm colors of red-purple *(top left most)* and central thinning *(white arrow)* on the pachymetry map represented by the warm colors of red-purple *(bottom left most)*. After IOP control, at 3 months resumption of normal posterior float shape *(top row middle figure)* with stability of normal posterior float shape at 6 months *(top rightmost)*. Pachymetry map showed resumption of normal thickness at 3 months *(middle bottom row)* with stability of thickness *(bottom rightmost)*.

pachymetry showed normal thickness at 591 um on the right and 599 um on the left with the calculated residual stromal thickness to be 350 um and 387 um on the right and left eye, respectively. Topography measurements showed normal corneal shape with regular astigmatism (Figure 3), and the IOP was normal. One week after surgery, the patient complained of slightly blurred vision UCVA 20/30 on each eye, with eye heaviness, and IOP was elevated in both eyes, 40 mmHg by Ehlers CF and 32 mmHg by Ehlers CF on the right and left eye, respectively. With the elevated IOP, this patient was also diagnosed to have steroid-induced ocular hypertension. The corneal topography showed ectatic characteristics in both eyes (Figures 4A and 4B). The topical steroid eyedrops were discontinued. The patient was given mannitol IV push followed by topical antihypertensive eyedrops. The OP was controlled the next day, with the improvement of vision to 20/20 on each eye. During follow-up appointments at 1 month and six months post-operation, vision remained stable, with normal corneal topography characteristics (Figures 4A and 4B).

Eyes with Ectasia

Patient C, a 33-year-old Caucasian male, had uneventful LASIK surgery on both eyes. His pre-operative measurements were -3.25 sph = -0.50 cyl x 30° spherical equivalent of 3.5D for the right eye and -4.00 sphere for the left eye showed regular astigmatism. Corneal thickness were 513 um on the right and 505 um on the left. The estimated calculated residual thickness ere 260 um and 253 um on the right and left eye. The pre-operative topography of the left eye showed a normal-shaped cornea (Figure 5). During follow-up appointments, the patient's uncorrected vision was stable, with normal topography showing regular morphology and central thickness. However, three years later, the patient's right eye has normal vision and topography pattern, but the patient complained of blurred vision in the left eye, UCVA 20/40, and topography showed inferior steepening and thinning (Figure 6). The patient was prescribed contact lens for the left eye and he was advised periodic monitoring. Eight years later, there was noted progressive blurring of vision on the left eye at UCVA 20/80 with manifest refraction of -3.75 sph = -1.75 cyl x 5°, while the right eye's vision was stable at 20/20 with plano refraction. The topography pattern on the right eye was stable, while the left eye topography map showed progressive inferior thinning (Figure 6). The patient was advised to continue wearing contact lenses and suggested collagen cross-linking on the left eye.

Patient D, a 28-year-old Filipino male, underwent LASIK for the right eye despite the amblyopia. His pre-operative manifest refraction was -2.00 sph = -1.00 cyl x 95°, spherical equivalent on the right eye was -2.5D with a best-corrected visual acuity of 20/80. Corneal thickness was 523 um with and estimated residual thickness of 253 um. Topography measurements showed a skewed radial axis with inferior steepening on the right eye (Figure7). Post-operative follow-ups were unremarkable where the right eye's UCVA was 20/80 and his post-operation topography map was similar to his pre-operative map (Figure 8). On his third month post-operative period, corneal topography showed inferior steepening, anterior and posterior float thinning were noted (Figure 8). By the eighth month, the right eye showed signs of ectasia with progressive blurring of vision, while the left eye remained normal. The patient was advised to do contact lens fitting for the right eye and periodic monitoring. On his 8th month follow-up, the patient noted blurred vision in the right eye. Uncorrected visual acuity on the right eye was 20/100 best-corrected to 20/80 using manifest refraction of -2.50 sph = 0.50 cyl x 130°. The right eye topographic pattern seems consistent with ectasia's topographic changes:

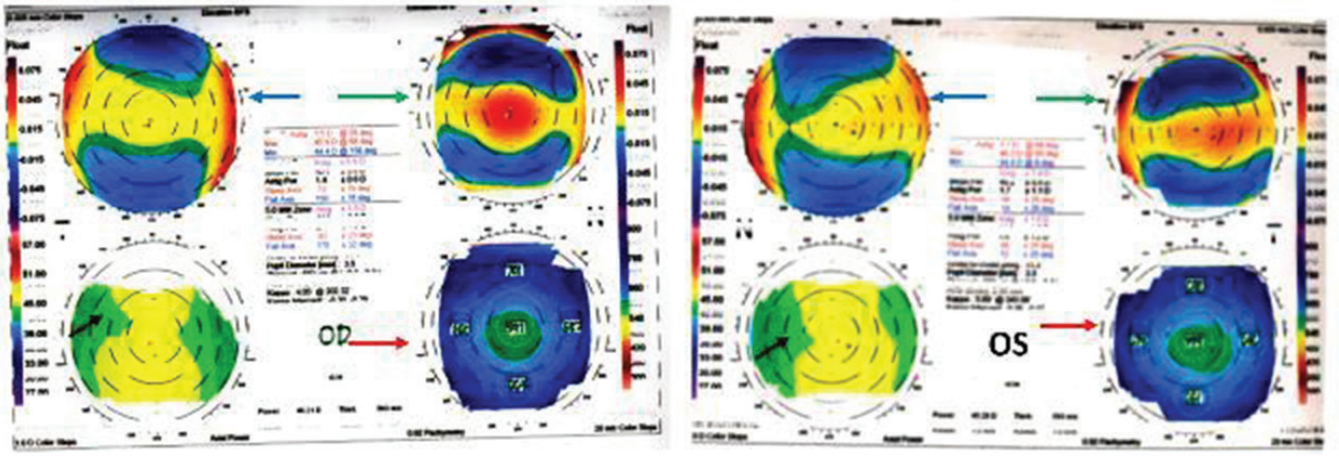

Figure 3. Topography showed a bilateral asymmetric bowtie pattern on the keratometry map. Black arrows on the keratometry map, showing an asymmetric bowtie via the yellow color on the right eye, and a larger asymmetric bowtie as indicated by the yellow color on the left eye. The anterior float *(blue arrow)*, posterior float *(green arrow)* and pachymetric or corneal thickness map *(red arrow)* were all normal.

inferior steepening on the keratometry map, steepening on both the anterior and posterior float, and thinning on the pachymetry (Figure 8). The patient was advised to do contact lens fitting for the right eye and periodic monitoring.

Risk Assessment

Based on the ERFSS, the cumulative risk assessment, Patients A and B are low-risk for ectasia while Patient C's left eye has moderate risk for ectasia as well as Patient D's right eye. (Table 3). This correlates how Patient A and B's ectatic changes reversed after managing the intraocular pressure. While Patient C (left eye) and Patient D (right eye) presented with real ectasia after the procedure.

Pre-operative Topography Pattern

Bowtie pattern represents the astigmatic pattern of the patient's eye. Patient A showed an asymmetric bowtie (Figure 1) in the pseudoectasia group, while Patient B had

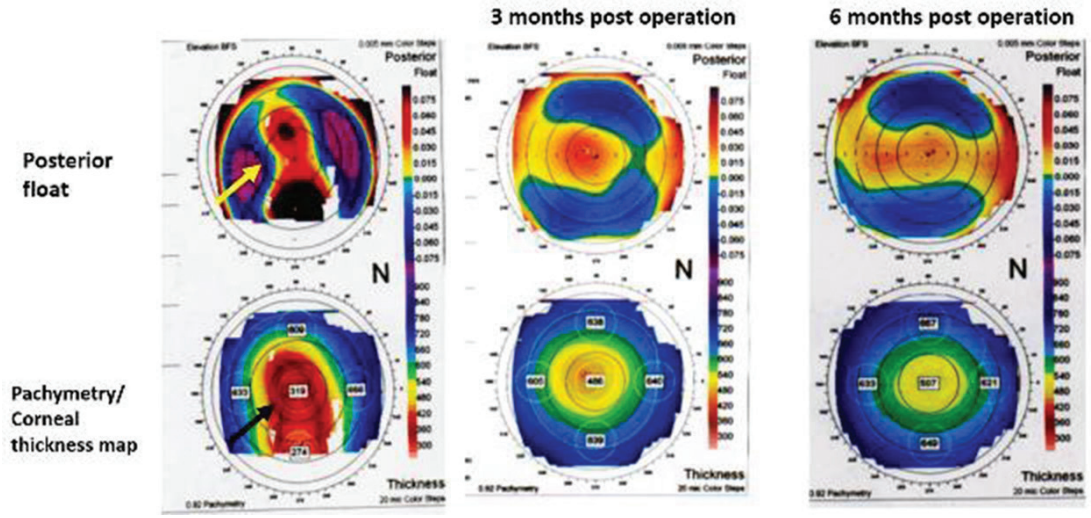

Figure 4A. ***Patient B Right Eye.*** At 2 weeks post-operation showing signs of pseudoectasia, yellow arrow points to thinning of the posterior float as indicated by the deep red-purple hues *(top left most)* and central thinning *(black arrow)* on the pachymetry map indicated by the dark red hues *(bottom left most)*. After IOP control, at 3 months resumption of normal shape of the posterior float *(top row middle)* with stability of normal posterior float shape at 6 months *(top rightmost)*. Pachymetry map showed resumption of normal thickness at 3 months *(middle bottom row)* with stability of thickness *(bottom rightmost)*.

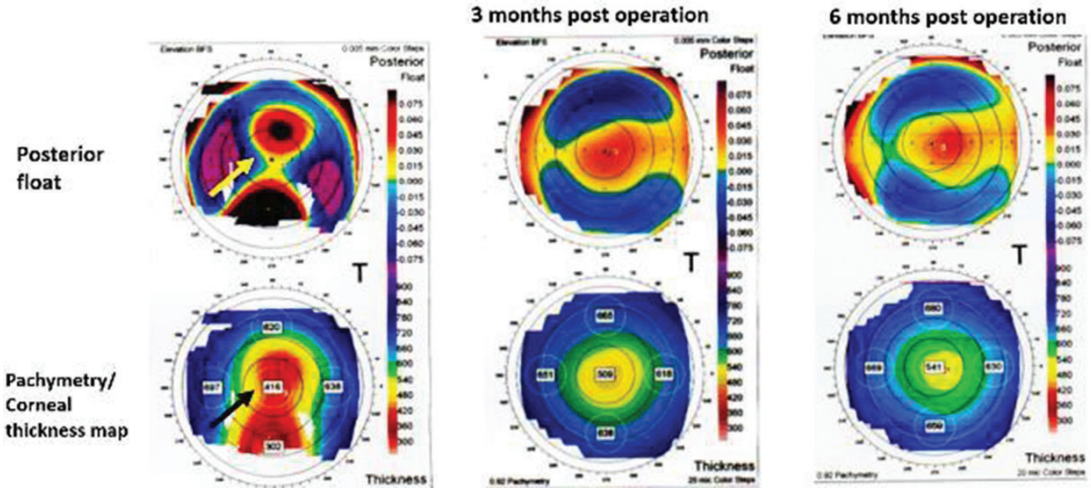

Figure 4B. ***Patient B Left Eye.*** At 2 weeks post-operation showing signs of pseudoectasia, yellow arrow points to thinning of the posterior float as indicated by the deep red-purple hues *(top left most)* and central thinning *(black arrow)* on the pachymetry map indicated by the dark-red hues *(bottom left most)*. After IOP control, at 3 months resumption of normal shape of the posterior float *(top row middle)* with stability of normal posterior float shape at 6 months *(top rightmost)*. Pachymetry map showed resumption of normal thickness at 3 months *(middle bottom row)* with stability of thickness *(bottom rightmost)*.

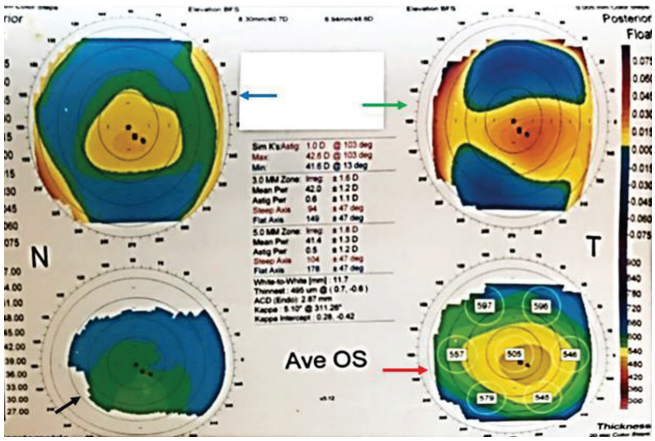

Figure 5. ***Normal-shaped cornea.*** The anterior float *(blue arrow)*, posterior float *(green arrow)*, keratometric map *(black arrow)* and pachymetric or corneal thickness map *(red arrow)* were all normal. The mean Keratometry is 42D *(3 mm zone)*.

a regular topography pattern (Figure 3). While in the ectasia group, Patient C showed an asymmetric bowtie pattern (Figure 5), a similar finding to Patient A, while Patient D's topography pattern showed inferior steepening and a skewed axis (Figure 7) in both eyes; patient D's pattern has the highest score in risks of ectasia in terms of topography among the four cases. (Table 3)

Residual stromal thickness

In the pseudoectasia group, Patient A had less than 300 um in computed RST, while Patient B was above 300 um. The RST for the pseudoectasia group scored 0 risks for patient B and 1 for patient A. For the ectasia group, Patient C's RST was at 253 um on the left eye, which is a score of 3 in terms of RST. It is noted that the RST of Patient D also belonged at the scored risk of 3, similar to the score of Patient C.

Age

In the pseudoectasia group, patients A and B age are at zero risk for ectasia as they were both in their 30s. For the ectasia group, Patient C was also in his 30s hence zero risk, similar to Patients A and B, while Patient D has a risk score of 1 because the patient is 29 years old. (Table 3)

Pre-operative thinnest cornea (um)

In both groups, the pre-operative thinnest cornea was all above 510 um, receiving a score of zero risk. (Table 3)

Pre-operative Manifest Refraction in Spherical Equivalent in diopters (D)

Both groups also scored zero risk in pre-operative refraction, having the pre-operative thinnest cornea all above 510 um, receiving a score of zero risk since all their pre-operative refraction were below -8D. (Table 2)

The difference between the groups was topography pattern risk and residual stromal thickness, with patient D having the highest risk. Patient C had a similar topography pattern to Patient A; however, the computed residual stromal bed thickness at 253 um separated Patient C from Patient A. Both Patients C and D had a score of 3 in the RST risk. (Table 3).

Other clinical parameters conventionally done during the post-operative period such as visual acuity is not part of the ERFSS. However, a decrease in visual acuity, as seen in both groups, was a clue for the clinicians to order a topography to check for the corneal shape. For the pseudoectasia group, the IOP was elevated at the time of the ectatic changes on topography and their refraction was low, while the ectasia group, the IOP were normal and the refractive error was high.

The findings showed that the ERFSS has a positive predictive value of 1. It could accurately predict the two eyes that developed clinical ectasia into moderate risk pre-operatively. At the same time, the patients with pseudoectasia were calculated pre-operatively as low risk.

Table 3. Application of the Ectasia Risk Factor Score System (ERFSS) on the Four Cases

ERFSS Criteria	Patient A	Score	Patient B	Score	Patient C	Score	Patient D	Score
Topography pattern	Asymmetric bowtie	1	Normal/ symmetrical	0	Asymmetric bowtie	1	Inferior steepening/ skewed radial axis	3
Residual stromal bed thickness (um)	280-299 (290, R; 288, L)	1	>300 (350, R; 387, L)	0	260-279 (260, R) 240-259 (253, L)	2 (R) 3 (L)	>300 (300, L) 240-259 (253, R)	3 (R) 0 (L)
Age (years)	>30 34	0	>30 31	0	>30 33	0	26-29 29	1
Preop Corneal Thickness (um)	>510 (522, R; 531, L)	0	>510 (591, R; 599, L)	0	>510 (513, R; 505, L)	0	>510 (523, R; 531, L)	0
Preop SE MR (d)	-8 or less (-4.87, R; -4.87, L)	0	-8 or less (-6.5, R; -5.13, L)	0	-8 or less (-3.5, R; -4, L)	0	-8 or less (-2.5, R; -2.5, L)	0
Cumulative Risk Factor Score	Low risk (right and left)	0-2	Low risk (right and left)	0	Low risk (R) Moderate risk (L)	0-2 (R) 0-3 (L)	Moderate risk (L)	0-3 (L)

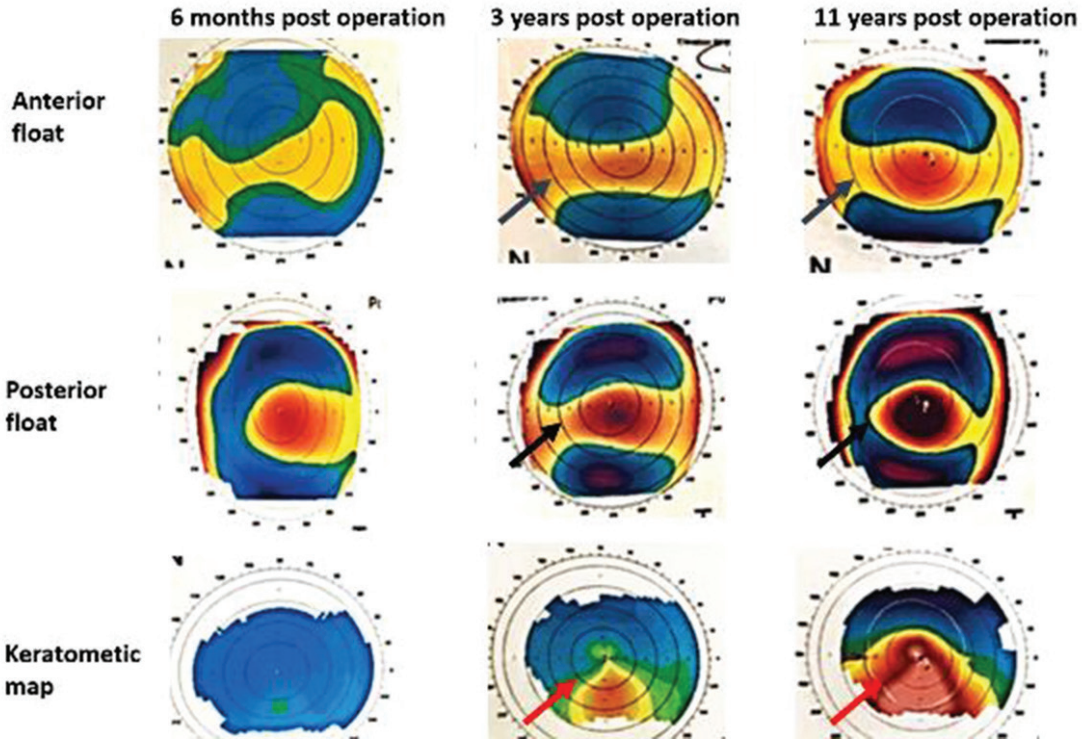

Figure 6. Patient C at 6 months post-operation, the topography was unremarkable. At 3 years post-operation, anterior float showed thinning as indicated by the red color *(blue arrow)*, same can be said for the posterior float *(black arrow)*. The keratometric map showed inferior steepening *(red arrow)*. At 11 years post-operation, there is noted progression of the thinning in the anterior *(blue arrow)* and posterior float *(black arrow)* as indicated by the darkening of the red colors, and increased in inferior steepening on the keratometric map *(red arrow)* indicated by the wider area and deeper hue of the red color.

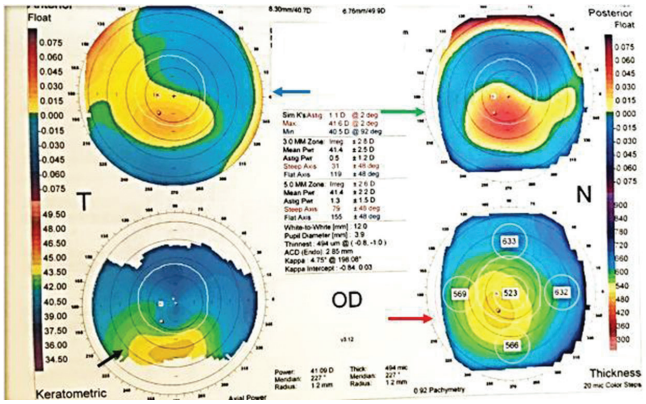

Figure 7. Patient D pre-operation showing a skewed radial axis with inferior steepening on the right eye *(black arrow)* showing the yellow color on the inferior area of the keratometric map. The anterior float *(blue arrow)*, posterior float *(green arrow)*, and pachymetric or corneal thickness map *(red arrow)* were all normal.

DISCUSSION

Corneal ectasia is a rare but serious complication that can occur after LASIK surgery. Although LASIK is a generally safe and effective procedure, corneal ectasia is a rare but serious complication that can occur after the surgery. Corneal ectasia is a condition where the cornea becomes progressively thinner and weaker, resulting in a bulging or protrusion of the cornea. This can cause a range of vision problems, including blurred vision, double vision, ghosting, and halos around lights. Corneal ectasia after LASIK surgery is thought to occur due to the thinning of the cornea, which can weaken the cornea's structure and cause it to bulge outwards. The exact cause of corneal ectasia after LASIK surgery is not fully understood, but it is thought to be related to the amount of tissue removed during the surgery, the age of the patient, the thickness of the cornea, and other factors.

Major risk factors for corneal ectasia prior to LASIK are abnormal corneal topography suggestive of keratoconus, pellucid marginal degeneration, forme fruste, highly myopic eyes, highly astigmatic eyes, eyes with steep corneas >47D, a preoperative pachymetry of 500 um or less, an estimated calculated residual bed thickness of 250 um or less, and in patients younger than 25 years.[5,7,9,10] After LASIK, It was

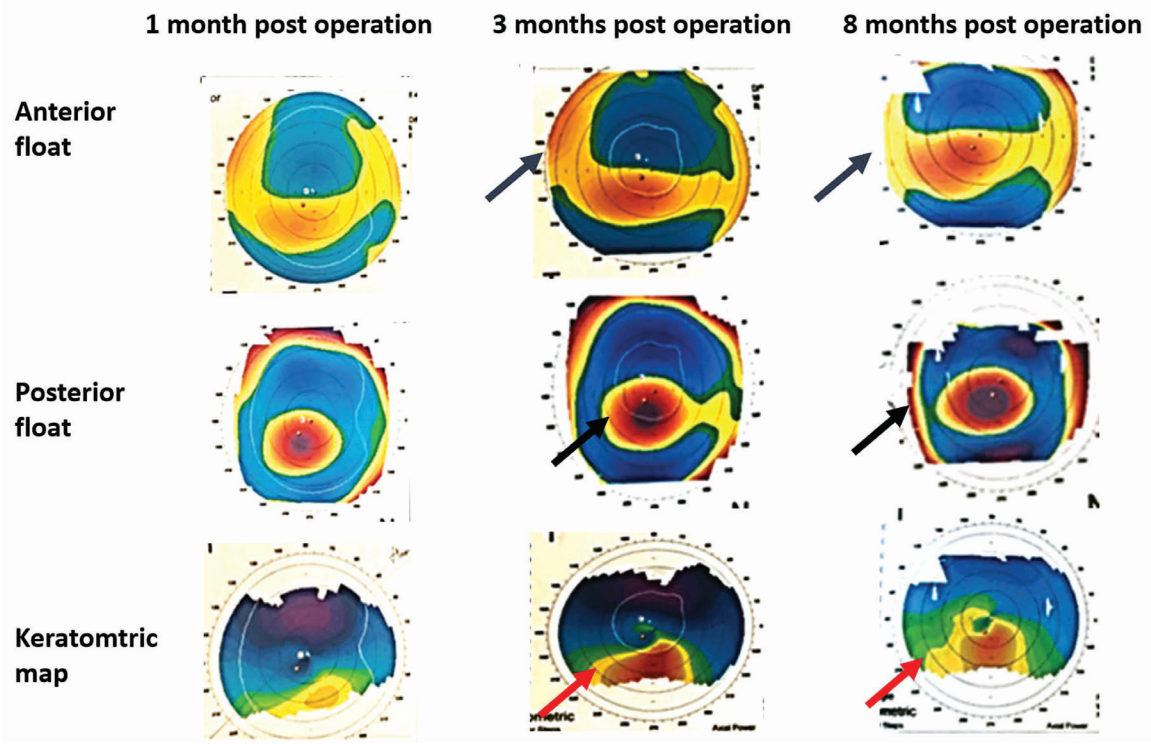

Figure 8. Patient D at 1 month post-operation anterior and posterior floats and keratometry map *(left most column)* were almost similar to pre-operative map *(see Figure 7)*. At 3 months post-operation there was thinning at the anterior *(dark blue arrows)* and posterior *(black arrows)* floats indicated by the red color and progressive inferior steepening of the keratometric map indicated by the red color *(red arrow)*. At 8 months post-operation further progression of the thinning of the anterior *(blue arrow)* and poster *(black arrow)* floats, and progressive inferior steepening on the keratometric map *(red arrow)*.

reported that a large amount of forward-shift occurs during the first post-operative week but continues for the next six months and remains stable. Since the tensile strength of the cornea is compromised significantly during the first few weeks post-LASIK, the cornea is more malleable to reshaping. Factors such as intraocular pressure and atmospheric pressure can influence corneal reshaping.[9]

Some reports discussed that ectasia can still occur even without these risk factors.[5,9,11] Those reports showed that excessive anterior bulging of the posterior corneal surface causes cornea thinning and may lead to corneal ectasia. The same topographic changes were seen in Patients A and B (Figures 2 and 4). As exhibited in both of these patients: the presence of posterior corneal surface bulging and thinner corneal pachymetric readings showed ectatic changes. These changes occurred in a setting of high intraocular pressure. Immediate discontinuation of steroids was done since the surgeon suspected that high IOPs were steroid-induced. The patients are two (Patient B) to four (Patient A) weeks on Prednisolone acetate (Pred Forte, Allergan, USA), and IOP-lowering drugs were given. With the control, there was immediate resolution in vision and reversal of the ectatic changes. Labeling this as pseudoectasia and looking at their ERFSS, both eyes of the two patients were tagged as low risk for developing ectasia.

Patients A and B could have Interface Fluid Syndrome, a rare incident. Interface Fluid Syndrome occurs when fluid accumulates between the corneal flap and the underlying stroma. The accumulation of fluid can cause a range of symptoms, including blurred vision, glare, halos around lights, and eye discomfort. One of the primary causes of IFS is the use of certain medications, such as topical steroids, which can increase the risk of IFS. Symptoms of IFS typically develop within the first few days or weeks after LASIK surgery. Patients may notice that their vision is blurry or hazy, and they may experience sensitivity to light. They may also see halos around lights or experience difficulty seeing at night.

It can also mimic diffuse lamellar keratitis (DLK), as in Patient B, where there was some fuzziness in the flap margin at 1-week post-operation. Hence steroids were not tapered. In LASIK, the flap interface is the potential space between the anterior and posterior corneal lamella wherein there is an area of low pressure and subsequently where fluid collects in patients with IFS.[12,13] In Interface Fluid Syndrome, patients would present with high IOP, as in Patients A and B. The early IOP control reversed the ectatic changes and improved the patient's vision. The corneal topography remained stable thereafter.

Patients C and D exhibited unilateral true ectasia, characterized by progressive thinning in the pachymetry, inferior

and central steepening on the keratometry map, and thinning on the anterior and posterior float. Patient C started to present at three years post-operation, while Patient D at three months, with progressive thinning on the topography map at six months. It is also noted that the two cases both have a risk score for Residual Stromal Thickness (RST) parameter, and both ectasia eyes had an abnormal topography pattern. This coincides with the findings of other studies[3,14], that pre-operative corneal topography pattern seems to be a high indicator of ectasia risk among all the parameters.

The Ectasia Risk Factor Scoring System (ERFSS) is a tool that helps to identify patients who may be at risk of developing corneal ectasia after refractive surgery. The scoring system takes into account several factors that have been shown to be associated with an increased risk of ectasia, including age, corneal thickness, preoperative refractive error, and topography. One of the potential benefits of the ERFSS is that it can help differentiate between true ectasia and pseudoectasia, which is a condition that can mimic the signs of ectasia but is not actually a progressive corneal thinning disorder. Pseudoectasia can occur due to factors such as dry eye, contact lens wear, or inaccurate measurements during preoperative evaluation. By identifying patients who are at higher risk for ectasia using the ERFSS, surgeons can take steps to minimize the risk of developing ectasia after refractive surgery. This may involve avoiding certain procedures or techniques, adjusting the treatment plan, or monitoring the patient more closely for signs of postoperative ectasia.

The ERFSS could determine true ectasia versus pseudoectasia with the four cases presented. The results in these four cases showed low-risk scores in the pseudoectasia group. The risks would also help clinicians identify which patients will likely develop true ectasia. Should patients who are low-risk develop ectatic changes, a differential diagnosis of pseudoectasia from fluid interface syndrome should be evaluated. Management of ectasia and pseudoectasia varies; thus, differentiating the two diseases is essential. Some studies presented by Chan et al.[14] show that the Randleman's ectasia risk factor scale can miss a significant proportion of patients at risk of ectasia in their study of 36 cases. They indicated that other factors contribute to ectasia, although abnormal corneal topography remains the most critical risk factor, which is in the ERFSS. Bohac et al.[3] noted the ERFSS retrospectively identified four high-risk and six medium- and low-risk cases. One eye in their series did not have risk factors but developed ectasia. It is important to note that the ERFSS should not be used as the sole criterion for determining candidacy for refractive surgery, as it is possible for patients with low ERFSS scores to develop ectasia and for those with high scores to remain stable. Each patient's individual risk factors and clinical history should be carefully considered before making any decisions about refractive surgery.

To help surgeons safely pursue LASIK procedures, newer concepts have been made to prevent ectasia formation. One is the "Percent Tissue Ablation (PTA)," representing the percentage of altered anterior corneal tissue before refractive surgery. In this theory, more than 40% PTA has been found to have the highest predictive risk of ectasia if computed correctly.[15] Second is the Screening Corneal Objective Risk of Ectasia (SCORE) Analyzer, a software linked to the Orbscan IIz topography system (Bausch & Lomb Technolas) designed to detect forme fruste keratoconus. In this program, the topography will be incorporated into the software, allowing it to analyze whether it is at risk for ectasia formation.[16] A positive or non-negative score will indicate a higher ectasia risk, while a negative score would indicate a lower chance of development. Despite the SCORE Analyzer's 100% specificity in predicting ectasia, global adaptation has been a significant hindrance in sharing this program because this software can only interpret the Orbscan topography results, and competition from emerging topographers makes it more unusable depending on the medical practitioner's preferential options in each country. In recent years, innovation in the Scheimplug-based Pentacam System, which is capable of creating a three-dimensional image of the cornea, incorporated the Belin-Ambrosio Enhanced Ectasia Display and progression analysis, which detects the topographic and tomographic analysis of the posterior and anterior cornea enhancing the capability for a more sensitive ectasia detection.[17] Also, the addition of Corvis software allows the detection of the biomechanical strength of the cornea prone to having post-operation ectasia.[18] This combined technology and the guide of ERFSS revolutionized ectasia detection, thus making it more straightforward to predict the diagnosis of ectasia formation, whether preoperatively or postoperatively.

The ERFSS is a classical pre-operative aide gauging a patient's risk for post-LASIK ectasia. It is not the be-all and end-all criteria to identify the risk of ectasia; however, it is a very good clinical guide. In a 20-year review done by Ambrosio, the classical risk factors mentioned in the ERFSS cannot be overlooked, but other factors must be considered.[19] Ambrosio suggests that the best strategy is still individualization of pre-operative screening, integrating objective clinical data, and the biomechanical impact of the procedure on the patient. In addition, ocular allergy, eye rubbing, and pressing on the eye may also be a factor in triggering ectasia, as reported by Bohac et al.[3]

The clinical application of the ectasia risk factor scoring system following surgery significantly aids surgeons to identify patients who are at higher risk of developing corneal ectasia. Furthermore, the implementation of an ectasia risk factor score system can assist surgeons to monitor patients more closely postoperatively. Patients who are at higher risk of developing ectasia may require more frequent follow-up appointments and additional testing to detect early signs of ectasia. By recognizing these patients early on, clinicians may monitor them more closely and give them appropriate therapies, such as additional corneal strengthening surgeries, to prevent the development of ectasia or anti-glaucoma medications as presented with pseudoectasia condition.

CONCLUSION

The Ectasia Risk Factor Scoring System (ERFSS) considers different risk factors that may increase the possibility of developing ectasia, such as corneal thickness and shape, the amount of corneal tissue removed after surgery, and the patient's degree of myopia (nearsightedness). ERFSS can help identify individuals who are at a higher risk of developing ectasia after laser vision correction surgery by examining these parameters and generating a numerical score. However, it is important to note that ERFSS is only one tool among many that can be used to assess a patient's risk of post-LASIK ectasia, and its usefulness is dependent on a number of factors, including the individual patient's characteristics and the surgeon's experience. Ultimately, any choice to proceed with LASIK surgery should be based on a thorough review of the patient's overall health, eye health, and risk factors. While ERFSS can be beneficial in predicting the possibility of ectasia, it is not perfect and cannot replace careful patient evaluation by an experienced eye care expert. Furthermore, ERFSS may be less efficient in identifying true ectasia from pseudoectasia in which additional diagnostic testing, like corneal topography, may be required in some circumstances to provide an accurate diagnosis. Ophthalmologists can use the ERFSS to identify patients who are at high risk of developing ectasia and take appropriate precautions, such as employing alternate refractive surgery procedures or closely monitoring patients post-operatively. This can improve outcomes and lower the risk of problems in refractive surgery patients.

The ERFSS is a good measure in deciding the suited treatment plan for patient undergoing refractive procedure. It is noted that all cases in this study occurred before the publication of the ERFSS, a sign that pre-operative screening and technology have become safer due to advancements in available technology, refinement of technique, and updates on pre-operative screening guidelines. Consistently reviewing and updating the risk factors of ectasia would hopefully further decrease the incidence in the future. In addition, knowing the clinical course of ectasia and pseudoectasia is helpful in the therapeutic approach since pseudoectasia is reversible when identified early.

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