A 23-year-old patient with a stable myopia for 3 years attended for refractive surgery assessment. Corrected visual acuity (CDVA) in the right eye (OD) was $-2.5 -0.5 \times 170 = 1$ and in the left eye (OS) was $-3.25 = 1$. The cycloplegic prescription was the same. Slit-lamp examination was normal. The intraocular pressure (IOP) in the OD was 15 mmHg and in the OS was 14 mmHg. Fundus examination was normal in both eyes. Ultrasound pachymetry was OD = 523 μm and OS = 557 μm. Schirmer’s test (Type II) was 20 mm in both eyes. Mesopic pupil diameter: 4.8 mm in both eyes. Elevation topography was performed (ORBSCAN II, Bausch & Lomb, Co) (Figures 1 and 2). The patient did not have any personal or family history of interest (keratoconus, atopy, etc.), and LASIK surgery was indicated in both eyes. The intervention was performed in March 2010, using femtosecond laser (IntraLase® iFS, Abbott Medical Optics) to create a flap thickness of 110 μm and flap diameter 9.5 mm. Refractive ablation was performed with an excimer laser (WaveLight® Allegretto 400, Alcon). F-CAT software with an optical zone (OZ) of 6.70 mm and ablation depth of 55.53 μm was used in the OD. The same software and OZ was used in the OS, with an ablation depth of 60.17 μm. There were no complications during the surgery or postoperatively. Six months after the intervention, the patient’s uncorrected distance visual acuity (UDVA) was 1.0 in both eyes with no residual refraction. The patient attended the clinic in February 2013 for a check-up due to reduced visual acuity in both eyes. On examination, UDVA in the OD was 0.4 (CDVA: $-1 -1.75 \times 70 = 0.8$) and in the OS the UDVA was 0.7 (CDVA: $-0.75 -0.75 \times 70 = 0.9$). Biomicroscopy and fundus examination were normal. The images obtained on elevation topography are shown in Figures 3-6. Postoperative corneal ectasia was diagnosed.

**Questions:**
Do you suspect any abnormalities in the patient’s history or preoperative tests?
Are the indications for the procedure, technique used and parameters adequate to prevent this condition?
Does using a femtosecond microkeratome have any advantage over a mechanical microkeratome in this situation?
Are there any routine diagnostic tests that could have detected a risk of postoperative ectasia?
In these cases, what is your procedure of choice and in which order?

If you use intracorneal rings, what would be their orientation, arc and thickness? Are there any special considerations in these types of cases?
If you use cross-linking, which technique and parameters would you use in this case?
In your clinical experience, have you obtained satisfactory results in the treatment of postoperative ectasia?
This is a patient who underwent surgery at 23-years-old in whom, 3 years later, central, bilateral post-LASIK ectasia was diagnosed, with asymmetric severity and unknown date of onset. The exact etiology of this entity is still not completely understood, debating between biomechanical instability induced by the surgery, the evolution of a chronic pre-existing sub-clinical process, or a combination of both.

There is controversy with respect to the relevance of various preoperative risk factors in the appearance of post-LASIK ectasia, such as: topographic abnormalities, age, minimal central pachymetry (MCP) and residual stromal bed\(^1\). The surgeon's challenge is to determine the probability of these complications arising when the signs of risk are very difficult to detect. All the preoperative parameters should be assessed as a whole, as none of the risk factors alone can predict the development of ectasia. Even so, ectasia can develop in eyes without identifiable risk factors\(^2,3\). In this case, there is a preoperative finding that draws attention due to its extreme rarity. A difference of > 30.4 μm between the MCP of both eyes occurs in < 0.5% of the population\(^4\), but the difference in this case is 34-40 μm. Significant differences have been related with the possible existence of forms of keratoconus\(^5,6\). This fact together with the patient's youth, a major risk factor\(^1\), could alert the surgeon and prompt a search for other established risk factors that could make surgery inadvisable\(^4\), such as positive results in topographic tests specific for the early detection of keratoconus. These include the recently marketed Belin/Ambrosio test used in the postoperative study in this case, the existence of significant posterior corneal surface elevation\(^1\) or an alteration in the corneal biomechanical factors\(^6\), all indicators of possible keratoconus and which we do not have in this case.

Although femtosecond laser provides better predictability and homogeneity in flap creation than the manual microkeratome, we are unaware of any studies that show a lower incidence of ectasia with the former, although conceptually this appears logical. Knowing the stromal bed pachymetry results before the ablation would have been advantageous, since the flap thickness may have significant variations with respect to the programmed value, even with the femtosecond laser platform used\(^7\), and thus affect the safety of the procedure.

With respect to the initial surgical treatment, and in view of the above, it would seem reasonable to defer the surgery until further preoperative data are obtained, especially Scheimpflug Imaging. The idea that a PRK would have been a reasonable alternative if more risk parameters had appeared is difficult to sustain due to the patient's age. The indication for a phakic lens would have been a plausible alternative. Another possible alternative would have been to combine the refractive laser surgery with a cross-linking treatment, although this remains a hotly debated indication.

Once the onset of ectasia has been observed, the first step is to control its progression. Although an arrest in the progression has occasionally been reported with intracorneal ring segments\(^8\), today our first choice treatment continues to be cross-linking. Nevertheless, we have one case of post-LASIK ectasia that we treated with intracorneal ring segments only, in which 5 years after the procedure, not only has the ectasia stopped progressing, but the cornea is showing gradual improvement of the keratometry in the apex. Right up to the surgery, we prescribe topical hypotensive medication to minimize corneal bulging. Of the cross-linking methods, the epithelial debridement technique has been used for longest. Debridement, in our experience, is not really a problem when the correct therapeutic contact lens is used for only the first three days postoperatively and

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Figure 4.

Figure 5.

Figure 6.
secondary diffuse lamellar keratitis, which may appear in the interface in these cases, is correctly managed with a short dose of topical steroids. Of utmost importance is the choice of a riboflavin combined with methylcellulose (MedioCROSS® M Riboflavin with HPMC 1.1%, Peschke GmbH, Hünenberg, Switzerland) which really acts as isoosmolar, thus not compromising the safety of the treatment by unexpected stromal thinning during the UV irradiation, as occurs with the usual riboflavin combined with dextran, erroneously named isotonic. Due to its obvious hyperosmolar effect (thinner, hyperoncotic) this may worsen the visual prognosis, even more so when the best corrected distance visual acuity is already reduced by an irregular astigmatism, as in the present case. Until we consider that the cornea is stable, we continue with hypotensive medication for three months after the treatment.

Once the progression has been halted, and if the vision with spectacles is not satisfactory, the following step is to reduce the irregularities in the corneal curvature to improve the visual quality. This can be achieved by adapting gas permeable contact lens while correcting the refractive error. In cases where wearing a contact lens is not satisfactory, the implantation of intracorneal ring segments aimed at regularizing the cornea may be chosen. In the present case, a triangular ring segment (Ferrara), 210 arc degree/150 μm in both eyes, would be indicated, with particular care to avoid the interface during the implantation and warning the patient that final emmetropia is unlikely. Although we do not have any experience with modified intracorneal ring segments (Intacs) in cases of post-LASIK ectasia, there are expert opinions that believe that this design is more advisable than the triangular to thus reduce the inflammatory component. Finally, if the patient insisted on dispensing with spectacles and/or contact lenses, once the ectasia had been halted and the cornea regularized, implantation of a phakic intraocular lens would be our procedure of choice.

REFERENCES


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In this case I cannot see any abnormalities in the patient history or diagnostic tests prior to the corneal refractive surgery. The procedure and technique seem appropriate, and the use of femtosecond laser to create the flap is correct.

If the option is available, personally I prefer to use the Pentacam or Sirius topography system, as their improved screening for detection of keratoconus or abnormal corneas is better. Additionally, if there is the option of epithelial maps, this could have helped us to determine if there were any corneal abnormalities in the initial stages.

Had any been detected, I would have opted for FemtoLasik or PRK, with Avedro XTRA accelerated cross-linking, indicated in these cases, especially in young patients.

In the treatment approach to ectasia, we need to decide whether it is advisable to place intracorneal segments.

If we decide to do so, we can see on the topography that the ectasia is inferior temporal and peri-central. In these cases, if we place two segments with the incision in the keratometric axis at 140 degrees, even if we place 160 degree/150 μm segments, the effect on the refraction would be so large that we would worsen the corrected (CDVA) and uncorrected (UDVA) visual acuities. If we place only one inferior segment, with an incision in the axis of the coma vector, also at 140 degrees, even with a 160 degree/150 μm segment, we would change the sphere and transform an irregular astigmatism into a regular one. We would somewhat improve the UDVA but perhaps not the CDVA. This is suggesting that we do not change the axis of the astigmatism or the coma, because if we do so, the visual acuity with and without refraction would decrease.

This is a case of ectasia, peri-central with certain asymmetry and low coma. As the patient has good corrected visual acuity, we would prefer to treat the ectasia with cross-linking, because the refractive change induced by the segment is unnecessary.

The natural tendency, if we do not treat it, is to increase the asymmetry, increase the coma and in time it will require an inferior segment and cross-linking.
In cross-linking, lately we have been using the Avedro epi-on system. Total energy 7.2/cm², UV power 45mW/cm². Total induction time 10 minutes: 4 minutes with Paracel-Transpemophil (0.25% riboflavin-HMPC) and 6 minutes with Vibex Xtra (0.25% riboflavin and saline) and with pulsed light 2 seconds ON, 1 second OFF.

Our experience in these ectasias is satisfactory, although less so than in keratoconus. The keratometric and visual acuity results are actually similar to those of epi-off cross-linking, although our series with epi-on is smaller than epi-off cross-linking, both in ectasia and in keratoconus. The left eye will certainly end up with ectasia. I would perform epi-on cross-linking as soon as possible, as in the right eye.

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This is a case of ectasia in a patient who underwent LASIK surgery two years previously. Post-LASIK ectasia is a rare condition, and although the incidence has not been clearly established, various publications have estimated it at 0.04% to 0.6%1. The factors most clearly associated with this disease are high myopia, thin residual stromal bed and topographic abnormalities. In this patient, risk factors apparently did not appear in the preoperative examination. This is a young myope, with no personal or family history of interest, with a low prescription and normal pachymetry, sufficient to correct his refractive error. Thus, the ablation necessary according to the indication programmed in the excimer was not high in either eye (55.53 and 60.17 μm). Moreover, the flap cut was performed with femtosecond laser, with a programmed thickness of 110 μm, which would provide greater safety and predictability to obtain an adequate residual stromal bed (greater than 350 μm in both eyes). It has also been reported that the impact on corneal biomechanics is lower with the femtosecond than with the microkeratome2. With respect to the topographic images provided by the Orbscan, no keratometric, pachymetric, elevation or astigmatism data can be noted that would contraindicate the surgery. A slight inferior temporal displacement of the thinnest point can be observed. The biomechanical integrity study of the cornea provided by the ORA may help to rule out structural alterations in those corneas with a higher risk of suffering ectasia after refractive surgery.

Despite the advances in diagnostic methods, we know that ectasia can sometimes appear without any apparent preoperative risk factors4.

The patient now has post-LASIK ectasia, with corrected visual acuity of 0.8 in the right eye and 0.9 in the left.

At present, only very advanced cases of ectatic corneas require keratoplasty. Prior to this, there are other therapeutic levels, such as reducing the intraocular pressure, wearing contact lens, intrastromal rings or cross-linking. The rings are known to be useful for regularizing the corneal surface and improving visual acuity5. The usefulness of cross-linking in these patients, basically to prevent the ectasia from progressing, has also been reported6. There are no clear criteria on when to use rings and when to use cross-linking. Due to the tectonic effect caused by intracorneal rings (with an obvious change in the corneal surface), as opposed to the objective of cross-linking, which is to strengthen and stabilize the progression of the ectasia, it seems reasonable to think that more deformed corneas with a significant decrease in corrected visual acuity would be candidates for intracorneal rings. This is compared to less deformed corneas with better visual acuities, in which the primary objective would be to strengthen the cornea and attempt to slow the advance of the deformity.

In this case, central ectasia can be observed in the Orbscan images, more advanced in the right eye, with low keratometry (maximum of 49.1 D in the right eye and 45.2 D in the left eye), minimal pachymetry greater than 470 μm in both eyes, and corrected visual acuity of 0.8 and 0.9, respectively. Due to the patient’s acceptably good visual acuity and refraction, I consider cross-linking most appropriate. Our aim is to improve the corneal biomechanics and stabilize the ectasia. We also know that with cross-linking, we can slightly reduce the Kmax and improve other topographic indices, which may lead to a reduction in corneal aberrations and improvement in visual acuity. With respect to the cross-linking technique, I would perform corneal epithelial debridement, as the scientific evidence published to date shows that this
technique is more effective, unlike transepithelial cross-linking, with more superficial and irregular absorption of the riboflavin. I would use a riboflavin formulation without dextran, so as not to thin the cornea (for better safety), and 30 mW/cm² ultraviolet irradiation, with a pulsed light protocol (1 s ON and 1 s OFF), 8 minutes of treatment and a total energy of 7.2 J/cm².

If the option for implanting corneal rings was chosen, with an essentially refractive objective to improve the visual acuity and regularize the corneal surface, I would choose a ring in a 5 mm optical zone (higher risk of halos), as this is a central ectasia and rings in the 6 mm zone are more astigmatic. It should be a fairly thin ring, due to the risk of flattening too much and inducing hyperopia. When it comes to planning surgery for post-LASIK ectasia, the presence of a flap must be taken into account, especially when performing manual tunneling.

In my experience of treating post-LASIK ectasia, I have obtained heterogeneous results, generally satisfactory. I believe that it should be treated promptly, and we must also take into account that this is a cornea with different biomechanical behavior to that of primary ectasia. This will mean that the improvement after cross-linking is generally less, and the effect of a corneal ring is also less predictable.

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This is a young patient with slight myopia in both eyes. The preoperative tests are normal, except for the corneal pachymetry, which shows asymmetry between the 2 eyes, 34 μm lower in the right eye compared to the left. Pachymetry is a very symmetrical parameter between both eyes, and an obvious difference may mask some conditions.

The difference in the central pachymetry and the point of minimal thickness (516 μm in the right eye and 556 μm in the left eye) should warn us to be cautious. I think that in this specific case I would not have indicated LASIK surgery, but rather subsequent annual checkups to observe the evolution of the various corneal parameters (topography, pachymetry, etc.).

The tests carried out on this patient are the same as those that I perform routinely in patients who are candidates for corneal refractive surgery. If in doubt, to detect early keratoconus, I use corneal hysteresis and the corneal resistance factor.

In relation to the microkeratome used, femtosecond laser is always safer than the mechanical microkeratome, in this situation and in any other.

Once post-LASIK corneal ectasia has been diagnosed, the management depends essentially on the patient’s corrected visual acuity (VA). In those eyes where the vision is 0.9/1.0 and the refractive error is small, my procedure of choice is cross-linking only (left eye of the clinical case). On the other hand, if the corrected vision is less than these values or the refractive error is large, the procedure of choice would be to place intrastromal corneal rings followed by cross-linking 6-8 weeks later (right eye of the clinical case).

In the present case, I would only use rings in the patient’s right eye. For example, Intacs SK rings (6 mm in diameter), with an incision at 135°, an inferior temporal ring 0.300 mm thick and a superior nasal ring 0.250 mm thick. To perform the cross-linking, I use a technique with epithelial debridement, impregnation with riboflavin for 10 minutes and application of ultraviolet light for 10 minutes (9 mW/cm²).

In the 8 or 10 cases that I have had to treat in my professional career, either with cross-linking alone or by combining intrastromal rings and cross-linking, the result has been satisfactory.

REFERENCES


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This is a case of development of corneal ectasia following refractive surgery in a young person with no significant risk factors. Randleman’s quantitative score\(^1\) for preoperative risk assessment for corneal ectasia after refractive surgery is based on: corneal topographic patterns, residual stromal bed thickness, age and preoperative corneal pachymetry. According to this system, the patient would have a score of 2 points due to his age, which is considered a low risk for ectasia, and it would therefore be recommended to proceed with the surgery. Similarly, the flap thickness and amount of tissue ablated do not give any indication of the complication that later developed.

The use of femtosecond laser for flap creation adds safety and predictability to the procedure. Creating a thin flap allows higher residual stromal bed thickness to be preserved, reducing the risk of ectasia.

With respect to the diagnostic tests that we currently indicate prior to this type of surgery, we perform evaluation of the corneal morphology using corneal tomography (Sirius, Pentacam or VisanteOmni), evaluation of total and epithelial corneal pachymetry using OCT (RtVue) and analysis of the corneal biomechanics using the Corvis (Oculus).

Using the corneal epithelium selective pachymetry map and the total corneal pachymetry map based on OCT (Optovue RtVue), developed by David Huang\(^2\), we can detect apical changes in the corneal epithelium of suspect corneas (Figure 7). We also assess the corneal biomechanics using a high-speed Scheimpflug camera (Corvis, Oculus), which in addition to measuring the intraocular pressure (IOP), gives us a series of parameters that, using logistic models, obtain indices that help to distinguish between normal eyes and those with sub-clinical keratoconus\(^3\).

With respect to treatment, these ectasias are usually central or paracentral, so I usually use two intracorneal rings with the same 150-degree thickness, with a 6 mm optical zone. The tunnels and incisions are made with femtosecond laser (Visumax, Zeiss), with the incision (in cases like this) in the steepest meridian. The thickness depends on the refractive defect present, which in this patient is probably 150 μm. In cases of eccentric ectasias with large comatic aberration, I am more favor of placing a single ring, guided by the corneal aberrometer (Sirius), which has software to help plan the surgery.

I have recently started to perform accelerated cross-linking using the KXL system (Avedro). I take advantage of the ring tunnels to apply the riboflavin (VibexXtra) and then use a pulsed light protocol: Total irradiated energy: 5.4 J/cm\(^2\) UV; Power 30 mW/cm\(^2\); Pulse cycle times: 2 s ON, 1 s OFF; Total treatment time: 4 min. Another good option is cross-linking with iontophoresis.

My personal experience in the treatment of postoperative ectasias is good, especially in cases that are detected early.

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