Laser Surgery in Keratoconus

For some patients, it may be best to postpone surgery and reassess the technology in a few years.

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Is it reasonable to perform excimer laser treatment in patients with keratoconus? The answer is a very qualified yes—depending on the patient's characteristics.

BACK TO BASICS

Before we determine when laser vision correction is safe in patients with keratoconus, we must go back to basics: What is keratoconus? The answer depends on whom you ask.

For the clinician, keratoconus is an ectatic, noninflammatory disorder in which corneal thinning and protrusion cause the cornea to assume a conical shape.[1] The biochemist would say that keratoconus is an imbalance in normal cell apoptosis due to insufficient processing of reactive oxygen and nitrogen species, and that excessive mitochondrial DNA damage results in subclinical corneal inflammation, stromal thinning, and abnormal regulation of wound healing. The geneticist would say that there are nine chromosomes associated with keratoconus. Lastly, the topography expert would point out that mild keratoconus has an increased area of corneal power surrounded by concentric areas of decreasing power; inferior and superior power asymmetry; or skewing of the steepest radial axes above and below the horizontal meridian, with a flat meridian reading of less than 51.00 D.[2]

Clearly keratoconus is a tough area for clinicians who have to deal with an individual patient in the chair in front of them. Some patients are easy to exclude from candidacy for laser vision correction. For instance, in the presence of advanced keratoconus with scarring, in patients dependent on hard gas-permeable contact lenses for reasonable BCVA, and in patients with extreme thinning requiring corneal transplant surgery, treatment should be either deep anterior lamellar keratoplasty (DALK) or penetrating keratoplasty. These patients should not undergo laser treatment, apart from the unusual circumstance of phototherapeutic keratectomy to flatten a raised area of corneal scarring to return the patient to contact lens wear.

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At the other extreme, there is reasonable clinical evidence to suggest that patients with unusual topography not falling into the pattern of keratoconus or ectatic disease can be safely treated with PRK.

SUPERFICIAL TREATMENT

Corneal fibers in the anterior cornea have interlamellar bridging fibers that help maintain the structural strength of the cornea. These fibers bifurcate at various depths in the anterior stroma, tying the anterior lamellar fibers together and providing structural support. In the deeper parts of the cornea, fewer bridging fibers are present. Because the posterior lamellar fibers run parallel to each other and lack bridging fibers, the deeper part of the cornea is less stable and more susceptible to shearing motion and distension. Hence, the more superficially we treat, the better.[3]

There is evidence that patients with forme fruste and mild keratoconus can be treated with PRK with

good short- and long-term results. If we apply Randleman et al's risk-assessment criteria for ectasia,[4] forme fruste keratoconus rates a point score of 4, putting the patient in the high-risk category. The corresponding recommendation is, "do not perform LASIK; safety of surface ablation has not been established."

THREE STUDIES

Three studies can help us decide what to do in this circumstance.[5-7]

Koller et al.[5] Topography-guided PRK was used to treat 11 eyes of eight patients with forme fruste keratoconus. Statistically significant reductions in manifest refractive error, corneal irregularity, and subjective ghosting occurred. There was no loss of BCVA, and seven eyes gained BCVA. After laser treatment, all eyes had a central thickness greater than 450 µm, indicating that these patients were carefully selected.

Cennamo et al.[6] Eighteen eyes with keratoconus (seven bilateral, 11 unilateral) underwent topography-customized PRK with the MEL 70 laser (Carl Zeiss Meditec, Jena, Germany). Patients were followed for 3 years, and improvements in mean keratoconic index, keratoconic severity index, and other keratoconic topography parameters were statistically significant, as were mean improvements in UCVA and BCVA.

Alpins et al.[7] This long-term analysis of 45 eyes with forme fruste keratoconus (n=21) or mild keratoconus (n=24) after PRK showed no keratoconus progression up to 10 years postoperatively. Thirty-two eyes were followed for 5 years and nine for 10 years. The take-home message is that these patients were carefully selected. Their mean age was 40 years, their BCVA was 20/40 or better preoperatively, their mean keratometry (K) reading was less than 50.00 D, and they had corneal and refractive stability for 2 years prior to treatment. No patient was under 25 years of age, and no signs of keratoconus were present upon slit-lamp examination. At 1 year, seven eyes lost 1 line of BCVA, but 16 gained 1 line.

EXACERBATING KERATOCONUS

On the other hand, there are reports of surface ablation treatments either inducing or exacerbating keratoconus. Malecaze[8] published the case of a 22-year-old French patient with mild preoperative refractive error and topographic asymmetry who underwent PRK and developed ectasia 4 years later. Reznik[9] detailed a 25-year-old man with uneventful bilateral PRK for moderately

high myopia; ablation depths were 70 µm in the right eye and 100 µm in the left. Preoperative topography revealed forme fruste keratoconus in the right eye. Five years postoperatively, the patient developed unilateral inferior keratectasia in the right eye with loss of BCVA.

Data suggest that surface ablation in carefully selected mild and forme fruste keratoconus patients can be effective and safe over the long term; however, evidence also points to a small number of individual cases that may worsen after laser treatment.

CROSSLINKING

Can corneal collagen crosslinking (CXL) make PRK safer in patients with keratoconus? Kanellopoulos[10] has used CXL followed 6 months later by topography-guided PRK in this patient population with success. More recently, simultaneous CXL and topography-guided PRK have been used to treat mild keratoconus.[11-13] Kanellopoulos[11] limited simultaneous treatments to patients with progressive keratoconus whose total corneal thickness was at least 350 µm after PRK. The Allegro Topolyzer (WaveLight AG, Erlangen, Germany), a customized platform for topography-guided ablation, was used to treat 198 eyes fitting these inclusion criteria. All treatment depths were less than 50 µm, the optical zones were kept to 5.5 mm to minimize tissue removal with a transition of 1.5 mm, and sphere and cylinder treatments were reduced empirically by 30%. Topical mitomycin-C 0.02% was applied for 20 seconds, followed by CXL using 0.1% riboflavin with ultraviolet-A (UV-A) light for 30 minutes.

Eyes treated with simultaneous PRK and CXL were compared with 127 eyes treated with sequential CXL followed 6 months later by PRK.[10] The simultaneous group performed better in terms of BCVA (P <.001), spherical equivalent reduction (P <.005), mean K reduction (P <.005), and corneal haze score (P <.002) at final follow-up.

Stojanovic[12] reported a smaller series of 12 eyes of 12 patients treated with topography-guided ablation (Pulzar Z1; CustomVis, Balcatta, Australia) immediately followed by CXL. At 1-year follow-up, patients had a mean improvement in BCVA and UCVA with no progression of ectasia. Kymionis[13] described a small series of 14 eyes of 12 patients with progressive keratoconus, also using the Pulzar Z1. With careful patient selection protocol, the expected corneal thickness following treatment was greater than 400 µm. The investigators prospectively treated patients

(mean age, 28 years) with topography-guided PRK immediately followed by CXL. Mean follow-up was 10 months, and patients experienced improved UCVA and BCVA and a reduction in K readings. The software of the Pulzar Z1 allows the use of a percentage of customization ranging from 0% to 100%. Zero is equivalent to conventional laser treatment, and 100% is equivalent to full customization. Topical mitomycin-C was not used.

VALIDATION

As clinicians, we are faced with a dilemma: Can the optimistic claims for this relatively new modality of treatment be justified by laboratory and clinical data? Certainly there seem to be valid reasons for performing simultaneous PRK and CXL:

1. The combination reduces the patient's time away from work.

2. CXL offers the advantage of depopulating keratocytes in the anterior stroma, which could reduce the possibility of haze formation. Haze reduction was statistically significant in Kanellopoulos' simultaneous PRK/CLX study.[11]

3. If CXL is followed by topography-guided ablation 6 to 12 months later, some of the crosslinked anterior cornea is removed, therefore reducing the potential benefits of CXL.

Surgeons and patients will have to make up their own minds based on the following assumptions:

1. We cannot currently diagnose keratoconus with a sufficient level of specificity.

2. Keratoconus is a diverse disease in its presentation and progression.

3. CXL is effective and promising, but it is still evolving as a treatment modality.

4. Topography-guided treatment algorithms are being refined; however, the current level of development does not provide surgeons with clear guidelines for correct topographic treatment in terms of capturing the image, registering the image, and delivering the treatment.

TAKE-HOME MESSAGE

- Patients with advanced keratoconus with scarring, those dependent on hard gas-permeable contact lenses for BCVA, and those with extreme corneal thinning should not undergo laser vision correction.
- There is evidence that patients with unusual topography but no signs of keratoconus or ectatic disease can be safely treated with PRK.
- Careful patient selection is crucial in the keratoconic population.

CONCLUSION

With these assumptions in mind, my current protocol for patients with keratoconus is as follows:

1. I treat moderate and advanced keratoconus with traditional corneal surgeries such as DALK and penetrating keratoplasty.

2. In patients with slightly abnormal topography that would not qualify as forme fruste keratoconus, I avoid LASIK and instead treat with surface ablation using topical mitomycin-C.

3. In patients over the age of 25 years with forme fruste or mild keratoconus, I document progression and then proceed with simultaneous topography-based surface ablation, followed by topical mitomycin-C 0.02% for 15 seconds and CXL. I limit the maximum depth of treatment to 50 µm and make sure that the total corneal thickness following PRK is greater than 400 µm.

4. For patients under the age of 25 years and those who would not have enough corneal thickness remaining after treatment, I suggest they wait and reassess the technology and the data over the next few years before undergoing laser treatment. ■

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