Laser Vision Correction for Forme Fruste Keratoconus After CXL

Is it safe?

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Forme fruste keratoconus (FFKC) is a key risk factor for the development of corneal ectasia after excimer laser ablation. Although many systems and indices have been described to facilitate earlier detection of this condition, the diagnosis is clinical and based on several factors, particularly topographic, tomographic, and pachymetric patterns. A patient who is diagnosed with FFKC and desires refractive surgery has a few options for how to proceed, including to forgo refractive surgery, receive an implantable collamer lens (Visian ICL, STAAR Surgical), or undergo laser vision correction (LVC) in combination with CXL.

It is generally accepted that excimer laser ablation weakens the cornea through the removal of corneal tissue and that CXL stiffens and strengthens the cornea. In flap extensiometry tests, CXL increased the elastic modulus of the human cornea by 4.5 times.[1] The Dresden protocol's epithelium-off (epi-off) approach to CXL as well as more recent iterations of CXL, such as epithelium-on (epi-on) and accelerated CXL, have shown efficacy in stabilizing clinically evident keratoconus.[2-4]

It stands to reason that CXL has the potential to offset the weakening effect of excimer laser ablation, making the procedure safer for patients with FFKC.

FACTORS AFFECTING SAFETY

Several factors can affect the level of safety afforded by performing CXL in conjunction with LVC in a patient with FFKC and an increased risk of postoperative ectasia.

▶ **No. 1: The exact CXL protocol used.** The two main variations from the Dresden protocol for CXL are epi-on CXL, which preserves the corneal epithelium, and accelerated CXL, which reduces the time required for CXL by increasing the intensity of UV-A irradiation. Results with epi-on and accelerated CXL have been mixed. Some investigators have reported stabilization of ectasia, whereas others have reported poorer results than with the Dresden protocol.[5] In general, demarcation lines with modified protocols tend to be more superficial and less well-defined than with the Dresden protocol.[6]

▶ **No. 2: The depth of excimer laser ablation performed and residual stromal bed thickness.** The greater the depth of excimer laser ablation, the greater the weakening effect thereof. This effect is magnified by the fact that the anterior cornea provides a greater percentage of the cornea's overall biomechanical strength. Besides this, ablating an eye that has previously undergone CXL removes anterior corneal tissue stiffened by CXL.

Although the depth of ablation and residual stromal bed thickness vary among patients, it is prudent to consider the literature related to LVC for patients with keratoconus. For example, the Athens protocol recommends a maximum central ablation depth of 50 µm or less and a residual stromal bed thickness of more than 350 µm.[7]

► **No. 3: The type of LVC.** Surface excimer laser ablation would be expected to weaken the cornea less than flap-based or lenticule extraction–based procedures, which disconnect or undermine a layer of anterior corneal stromal tissue from the underlying stromal bed.

► **No. 4: Timing and order of LVC vis-à-vis CXL.** Excimer laser ablation and CXL may be performed simultaneously or consecutively/sequentially. Performing CXL after rather than before excimer laser ablation, whether at the same sitting or sequentially, is likely to provide greater strengthening effects because, as mentioned earlier, performing the reverse (ie, ablation after CXL) would remove some of the crosslinked cornea. Performing CXL after excimer laser ablation, however, means that the surgeon cannot take the corneal flattening produced by CXL into account when performing laser ablation, leading to somewhat greater refractive unpredictability.

> "If faced with a patient with FFKC who is keen for LVC, I would prefer PRK followed at the same sitting by epi-off CXL ... based on the long-term data available with this approach."

AN UNCLEAR ANSWER

It is difficult to say definitively whether LVC for FFKC after CXL is safe. Only short-term (6-month) data on the visual benefits are available.[8] Simultaneous same-session PRK followed by CXL has been shown to provide better visual results than CXL followed by PRK several months later.[9] There are also no long-term data on the rates of ectasia progression when CXL is followed by delayed excimer laser ablation.

More data are available on simultaneous excimer laser ablation and CXL. In a study with 10 years of follow-up, 94% of patients with keratoconus who underwent PRK immediately followed by CXL showed stability of their ectatic condition.[10]

WHAT I WOULD DO

If faced with a patient with FFKC who is keen for LVC, I would prefer PRK followed at the same sitting by epi-off CXL (in a similar fashion as described in the Athens protocol) based on the long-term data available with this approach. PRK debrides the corneal epithelium, and epi-off CXL promotes riboflavin saturation of the corneal stroma, optimizes the transmission of UV-A light, and allows atmospheric oxygen unimpeded access to the corneal stromal tissue.

A potential drawback to this approach is the possibility of gradual corneal flattening in the long term, as reported with the Dresden protocol. In a recent study using the Athens protocol, the mean maximum keratometry reading decreased from 46.17 to 44.75 D over 10 years.[10] Some accelerated CXL protocols that reduce delayed corneal flattening[6] may be considered when refractive predictability is a priority and there is less concern about the postoperative progression of ectasia.

In a patient who has already undergone CXL for FFKC and is interested in LVC, it is important to consider the type of CXL performed, the refractive and topographic corrections required, and the associated ablation depth.

Because the demarcation line seen with the Dresden protocol has a depth of approximately 300 µm, a superficial ablation removing perhaps 50 to 100 µm of anterior

corneal tissue may leave behind a sufficient amount of crosslinked tissue to prevent ectasia progression. Epi-on and accelerated protocols tend to produce less well-defined and more anteriorly positioned demarcation lines,[5,6] suggesting a higher chance of ablating more of the crosslinked tissue in such cases and an associated higher likelihood of future ectasia progression.

CONCLUSION

Unfortunately, some variables are currently unquantifiable, such as how much crosslinking/biomechanical stiffening is required in a particular eye to prevent the development or progression of ectasia and how much weakening a certain amount of laser ablation will cause. Because of these uncertainties and the lack of long-term data on excimer laser ablation performed at a later date than CXL, caution is required. Delaying laser ablation until after CXL should entail regular postoperative follow-up and possibly repeat CXL if the ectasia progresses.

In my opinion, performing LVC for FFKC sequentially after CXL is less safe than performing PRK followed by CXL at the same sitting. The former approach is best adopted as part of ongoing long-term studies assessing visual results and the risk of postoperative ectasia. ■

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