Keratoconus

Not too long ago, the options for treatment of keratoconus were limited to contact lens wear or penetrating keratoplasty. Times have changed, which is reflected in 4 articles in this issue that have some bearing on current investigation and treatment options.

One hundred fifty years ago, Dr. John Nottingham provided the first detailed description of keratoconus, with further observations by his contemporary Sir William Bowman.[1] It was then more than 120 years before clinical and laboratory research provided deeper understanding of the disorder.

Keratoconus is a noninflammatory condition that results in corneal thinning in central and paracentral areas of affected corneas. As the condition progresses, the inevitable astigmatism invariably changes from regular to irregular. The ultimate degradation is scarring and hydrops. However, modern technology offers therapeutic solutions to stop or at least slow the thinning process by corneal collagen crosslinking (CXL) (not yet approved in the United States despite 10 years of research proving its effectiveness in stiffening the cornea in keratoconic and ectatic eyes). Irregularity may be neutralized at least in part by corneal ring insertions, toric phakic intraocular lens (pIOL) implantation, or both.

It seemed counterintuitive to apply corneal excimer ablation technology to the treatment of mild degrees of keratoconus and to eyes believed to be exhibiting forme fruste of the disorder[2,3] when significant diagnostic efforts were being made to avoid treating such eyes with that technology for fear of causing ectasia. By stiffening the biomechanics of the cornea through collagen fiber crosslinking, a much stronger argument can be posed for pursuit of that stratagem. Corneal CXL is now widely performed internationally, with evidence of its effectiveness in stabilizing the progressive nature of keratoconus.[4] Touboul et al. (pages 1049–1055) continues the discussion by posing the question, Is topography-guided custom photoablation predictable in keratoconic eyes or those with irregular astigmatism? In their study, Placido topography is used to characterize the role of the corneal epithelium in living human keratoconic eyes after epithelial removal. This is based on the potential for corneal epithelial remodeling after photoablation. Their rationale is the increased interest in keratoconus management by photorefractive keratectomy now that corneal CXL is available internationally, as surgeons continue to look for ways to improve the predictability of visual outcomes. Photorefractive keratectomy removes Bowman membrane centrally to a 6.0 mm to 8.0 mm diameter. Corneal CXL is performed some weeks after the laser ablation[4,5] or as a same-day procedure[6] when allowance has to be made for the actual refractive error to be treated. Touboul et al. postulate that epithelial regrowth after surgery may decrease the surface irregularity and further improve the outcome. They conclude that "[t]opography-guided custom ablation is still a logical approach to treat the keratoconus surface irregularity; however, the role of the epithelium must be considered to be a consistent confounding factor for photoablation settings, especially when the refractive accuracy is targeted."

Is CXL's effectiveness dependent on epithelial removal before application of ultraviolet-A (UVA) irradiation after the cornea is dosed with riboflavin? That is the question. In their study of transepithelial CXL in a cornea treated by proparacaine preserved with benzalkonium chloride 0.005%, Koppen et al. (pages 1006–1011) conclude that this treatment was less effective than standard CXL in stabilizing progressive keratoconus. Whether the corneal epithelium is removed, another question is the potential harmful effects of CXL on limbal stem cells. This is considered by Thorsrud et al. (pages 1078–1082), who confirm the 2004 work of Wollensak et al.[7] in their in vitro investigation of inhibited regeneration of human limbal epithelial cells after riboflavin–UVA exposure. The basis for their study was concern that riboflavin–UVA CXL treatment has a cytotoxic effect on limbal epithelial stem cells.[7,8] While UVA irradiation alone may damage corneal epithelium, keratocytes, and endothelium, riboflavin acts as a photosensitizer and significantly increases the UVA absorption in the corneal stroma. In a study of cultured porcine keratocytes, vital stains were used as markers for damage induced by riboflavin–UVA irradiation.[9] Evident cytotoxic effect was observed at levels of treatment that may be reached in a clinical setting. Thorsud et al.'s study confirmed that the combination of riboflavin and UVA on limbal epithelial cells in vitro significantly reduces their regenerative capacity and induces apoptosis. With clinical application of CXL expanding year by year, it is evident that avoidance of the limbal area during the CXL procedure is a prerequisite of treatment.

The role of pIOLs, ie, toric pIOLs, is dependent on neutralization of irregular astigmatism, an inevitable aspect of progressive keratoconus. The use of pIOLs to improve the uncorrected vision of eyes with keratoconus must surely depend on stability of the cornea. Whether intrastromal corneal ring segments alone will provide that long-term stability or will require

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additional CXL remains to be demonstrated. Kurian et al. (pages 1056–1063) assess the visual quality after posterior chamber pIOL implantation in keratoconic eyes and note that "associated aberrations had an adverse impact on the ultimate visual quality and have to be addressed," confirming the above proposition.

With the latest technology providing diagnostic information and improved therapeutic options, keratoconus sufferers can look forward to significantly better understanding and more predictable outcomes than obtained a generation ago.

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REFERENCES

1. McGhee CN. 2008 Sir Norman McAlister Gregg Lecture: 150 years of practical observations on the conical cornea – what have we learned? Clin Exp Ophthalmol 2009; 37:160–176
2. Alpins N, Stamatelatos G. Customized photoastigmatic refractive keratectomy using combined topographic and refractive data for myopia and astigmatism in eyes with forme fruste and mild keratoconus. J Cataract Refract Surg 2007; 33:591–602
3. Hardten DR, Gosavi VV. Photorefractive keratectomy in eyes with atypical topography. J Cataract Refract Surg 2009; 35:1437–1444
4. Kanellopoulos AJ, Binder PS. Collagen cross-linking (CCL) with sequential topography-guided PRK; a temporizing alternative for keratoconus to penetrating keratoplasty. Cornea 2007; 26:891–895
5. Kanellopoulos AJ. Comparison of sequential vs same-day simultaneous collagen cross-linking and topography-guided PRK for treatment of keratoconus. J Refract Surg 2009; 25:S812–S818
6. Stojanovic A, Zhang J, Chen X, Nitter TA, Chen S, Wang Q. Topography-guided transepithelial surface ablation followed by corneal collagen cross-linking performed in a single combined procedure for the treatment of keratoconus and pellucid marginal degeneration. J Refract Surg 2010; 26:145–152
7. Wollensak G, Spoerl E, Reber F, Seiler T. Keratocyte cytotoxicity of riboflavin/UVA-treatment in vitro. Eye 2004; 18:718–722. Available at: http://www.nature.com/eye/journal/v18/n7/pdf/6700751a.pdf. Accessed February 27, 2012
8. Wollensak G, Spörl E, Reber F, Pillunat L, Funk R. Corneal endothelial cytotoxicity of riboflavin/UVA treatment in vitro. Ophthalmic Res 2003; 35:324–328
9. Wollensak G, Spoerl E, Wilsch M, Seiler T. Keratocyte apoptosis after corneal collagen cross-linking using riboflavin/UVA treatment. Cornea 2004; 23:43–49