Ultra Dk Contact Lenses

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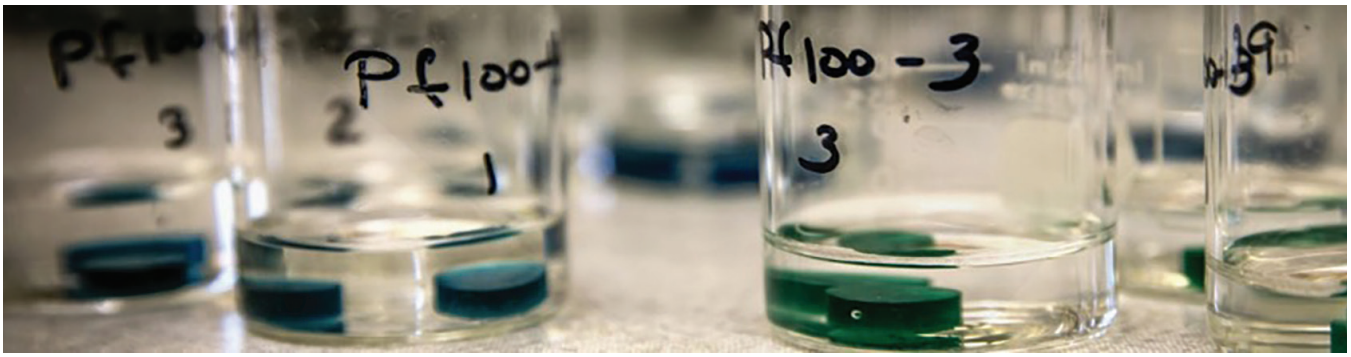

IMAGE COURTESY OF ACUITY POLYMERS

FIGURE 1: Acuity GP contact lens material prototypes.

The market for contact lenses is ever growing and the requirements and demands from the users and clinicians are extensive: disposable, comfortable, increased wear time, overnight wear, corneal reshaping, handling (cleaning, ease of use), cost, geometric and optical properties, and high oxygen permeability. While Efron wrote an obituary for rigid gas permeable (RGP) lenses over a decade ago, the use, applications, and design technologies of RGPs has continued to grow and expand.[1] The evolution of hard/rigid contact lens material started with glass in 1887, non-gas permeable polymethyl methacrylate (PMMA) in the 1940s, and the first rigid gas permeable material in the 1970s. Although Efron's prediction may not have come to pass, there has been a lack of material innovation for RGP lenses over the past decade. It has taken industry veterans, Dan Bell, Jim Bonafini, and Jonathan Jacobson coming together to form Acuity Polymers, Inc., to deliver the world's first Ultra Dk gas permeable material with the Acuity 200™ (fluoroxyfocon A).

Material innovation considers factors such as the mechanical properties, lens thickness, wettability, water content, and oxygen permeability. To deliver the desired properties, material scientists innovate more than just the polymer itself, rather the refinement of the polymerization recipe (e.g., temperature, initiator type, vessel used). The team at Acuity Polymers has delivered not only Ultra Dk, but a material with exceptional wettability, stability, durability, and deposit resistance.

Dk is the permeability of a material to oxygen, and coupled with lens thickness (t), it determines how much oxygen reaches the cornea through a specific contact lens (Dk/t).[2] Insufficient oxygen to the cornea creates both short- and long-term physiological changes, such as endothelial blebs, oedema, limbal injection, and corneal vascularisation.[3]

To avoid corneal oedema, a Dk/t of 24 for daily wear and 87 for extended wear has been proposed.[3] To avoid anoxia, this DK/t value is 35 during open eye and 125 during closed eye. The Acuity 200™ Ultra Dk polymer is of particular interest in scleral contact lenses due to the increased thickness of the lens and increased tear fluid reservoir thickness, corneal graft, and the correction of extreme ametropia.

Scleral Lenses

Modern scleral lenses have contributed to a resurgence in rigid gas permeable material use through the therapeutic treatment of the ocular surface, visual restoration of the irregular cornea and the correction of astigmatism.[4] While scleral lenses are life-changing for many wearers, they generate hypoxic stress as the contact lens and the underlying tear reservoir act as barriers to atmospheric oxygen.[5] Unlike corneal RGPs, no further oxygen is transmitted by movement of the tear film, as the tear reservoir is fairly stagnant.[6] Furthermore, most of the therapeutic and visual restoration indications are in eyes with compromised cornea and ocular surface that often

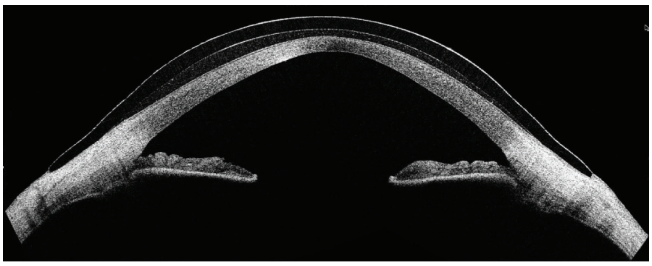

FIGURE 2: OCT of scleral contact lens.

cannot tolerate oxygen deprivation (e.g., corneal graft, Stevens-Johnson syndrome, corneal ectasia).[6–8]

Scleral lens wearers with keratoconus and a corneal graft tend to experience an increase in corneal thickness due to oedema by an average of 2% to 4% throughout the day.[9,10] This may seem insignificant as the cornea swells by 4.5% overnight with eye closure but recovers once awake over the course of the next hour.[9] However, the hypoxia-related stress secondary to scleral lens wear occurs rapidly, within the first 45 minutes, and can last for up to 150 minutes after removal.[11] Furthermore, as scleral lenses are worn to reduce ocular pain and in visual restoration unachievable with spectacles, wearers have a tendency to wear their lenses for long hours, often inserting straight after waking and only removing the lens just before bed. As a result, there is little time for the cornea to recover from the physiological oedema it endures overnight before lens-induced oedema begins. While the scleral lens induced oedema is low grade, the long-term physiological effects are unclear.[6]

It has been observed that scleral lenses with Dk values >163 minimize oxygen depletion in the cornea. Theoretical models have approximated that to minimize hypoxic stress, scleral lenses should be manufactured from materials with Dk ≥150, lens thickness ≤250µm and tear reservoir 100-150µm.[6,12,13] The evidence is clear that the highest Dk material available should be used when possible.

Corneal Rigid Gas Permeable

As disposable contact lenses dominant the correction of most ametropia, corneal RGP lenses are typically

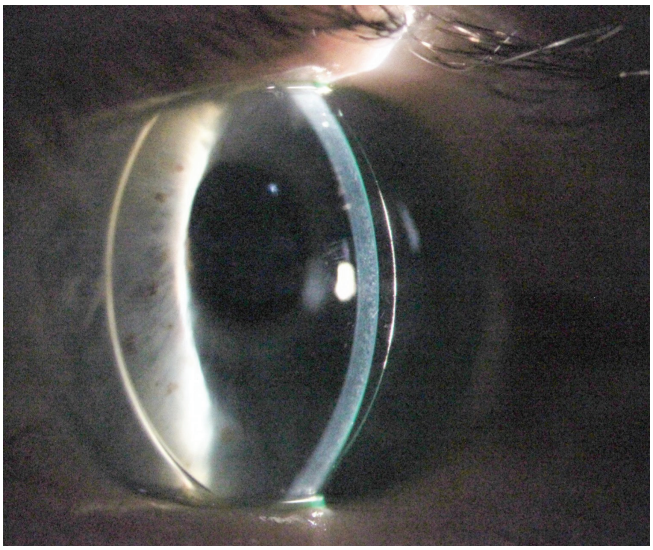

FIGURE 3: A corneal acuity 200 +18.00D for aphakia.

reserved for extreme ametropia and irregular cornea. The correction of extreme ametropia requires high BVP thick lenses.

As discussed above, thick lenses reduce oxygen permeability, and therefore should be made of the highest Dk possible to minimize any hypoxic stress.

Corneal Graft

While the most obvious sign of hypoxia is in the stroma (corneal oedema), oxygen deprivation also occurs at the epithelial and endothelial levels.[14,15] While the epithelium is able to regenerate and recover from hypoxic stress,

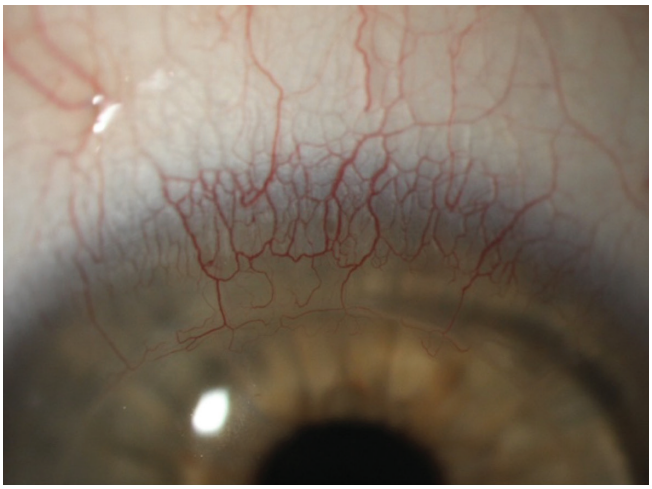

FIGURE 4: Vascularization of a corneal graft.

the same cannot be said for endothelial cells. This is particularly pertinent for corneal graft recipients (PK and DALK).

The average age of corneal graft donors is 65, a demographic that is vulnerable to endothelial cell dysfunction and dystrophies.[16] Hypoxia serves to exacerbate the endothelial disease process and drives neovascularization and inflammation, increasing the likelihood of graft rejection, and ultimately, shortening the lifespan of the graft. Unfortunately, many corneal grafts result in major and irregular astigmatism, and require contact lenses to restore visual quality. Every effort must be made to minimize any hypoxic or inflammatory stress on these eyes by using the highest Dk material possible and using corneal RGP lenses where possible. However, sometimes the irregularity reaches a point where corneal lenses are unable to be fit and a scleral lens is the only option precluding regraft. Using an Ultra Dk material allows scleral lenses to be fitted in the application of corneal graft with greater confidence in the long term health and survival of the tissue.

Case Report

A 76-year-old female had penetrating keratoplasty in 1976 for keratoconus. While the central cornea was clear, there was 24D of corneal astigmatism, and the junction of the graft was cloudy with existing neovascularization

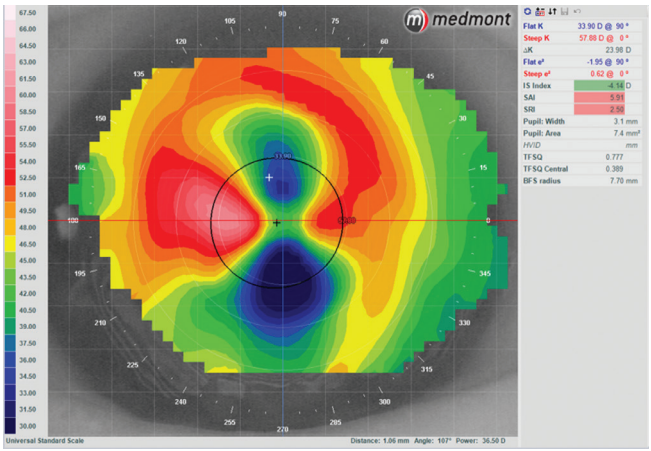

FIGURE 5: Topography showing corneal toricity measuring 23.98D.

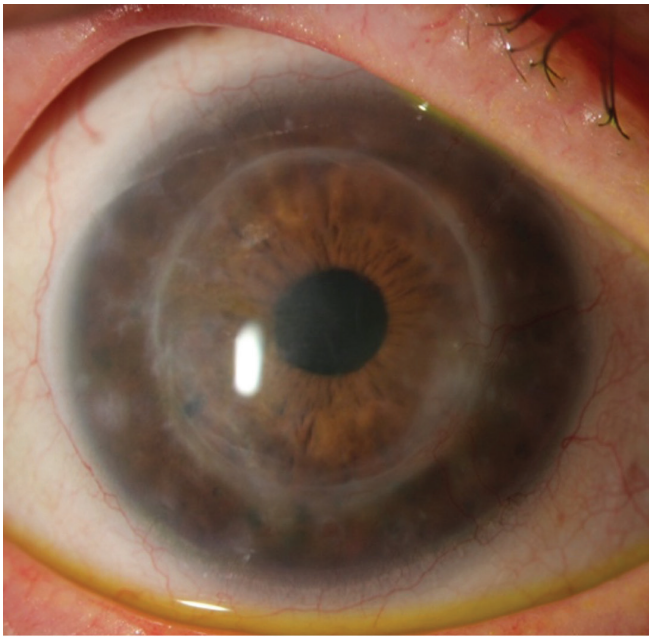

FIGURE 6: Corneal graft shows signs of rejection including opacification and neovascularization.

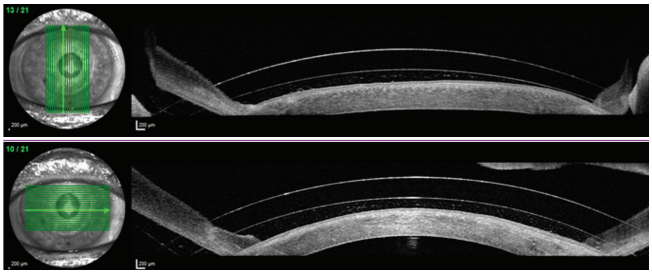

FIGURE 7: Horizontal and vertical B-scans from the anterior OCT of the scleral lens vaulting over the corneal graft.

To deliver the desired properties, material scientists innovate more than just the polymer itself, rather the refinement of the polymerization recipe.

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superior and nasal. She was fitted with a scleral lens made of Acuity 200™ material in 2018.

EyeSpace Scleral
9.0/4150µm/39°/17.5
7.0/4550µm/40°/
BVP: +6.00D / -10.50D x 180.0°

The lens provided excellent vision, the cornea remains clear, and there has been no evidence of advancing neovascularization. The graft continues to survive, and she remains happy wearing contact lenses. ■

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