Improving Clear Corneal Wound Integrity

In situ-forming hydrogel bandages mimic living tissue.

BY DANIEL CALLADINE, MRCOPHTH, BMBS, BMedSci

Hydrogels, which mimic living tissue more than any other synthetic biomaterial because of their high water content and tensile strength, have numerous clinical applications in ophthalmology. Their soft, rubbery consistency can minimize friction with surrounding cells and tissue, and their degree of flexibility is similar to the eye’s natural tissues. Polyethylene glycol (PEG), the main component in many hydrogels, is commonly found in drugs, implants, and injectables. Use of hydrogels also avoids the risks associated with medical technologies based on biological components such as human thrombin materials.

Currently, two ocular bandages made from PEG hydrogels are commercially available in Europe: the ReSure Adherent Ocular Bandage (Ocular Therapeutix, Inc., Bedford, Massachusetts) and OcuSeal Liquid Ocular Bandage (Roundtable Healthcare Partners, Lake Forest, Illinois).

I have used both products, but I prefer ReSure for the following reasons:

• Its foam-tipped applicator enables accurate placement over the incision;
• Up to four transfers of material can be obtained from each mixture before it polymerizes, which is particularly useful when applications are made at different stages of the procedure; and
• A visualization aid (FD&C Blue No. 1) helps determine thickness and placement of the application, especially on a transparent surface such as the cornea. The dye thereafter diffuses from the hydrogel and leaves behind a transparent material within 1 or 2 hours.

The PEG component of the hydrogel is supplied as a powder that, when mixed with a diluant, forms a blue precursor (Figure 1). I recommend mixing these components approximately 5 minutes before the surgeon is ready to use the hydrogel. First, a drop of the blue precursor and a drop of an accelerator solution (buffered sodium phosphate tetraborate decahydrate) are placed on a hydrophobic foil pouch (Figure 2). Once the blue precursor and accelerator are mixed, they react to form the hydrogel in approximately 30 seconds.

APPLICATION TIPS

Tip No. 1: The ocular surface at the site of application must be dry to achieve appropriate adhesion. If applied to a wet surface, the hydrogel will migrate with the fluid before it has time to polymerize over the wound. I have found the best method for application is to place a cellulose spear or surgical sponge over the wound with one hand until the hydrogel is applied with the other hand.

Figure 1. The scrub nurse interlocks the PEG powder syringe with the diluent syringe to create the blue precursor.

Figure 2. (A) A drop of blue precursor (top) and a drop of accelerator solution (bottom) are placed on the foil packet. (B) The surgeon uses the blunt end of the foam-tipped applicator to mix the two components and activate polymerization. (C) The foam-tipped end of the applicator is used to transfer the hydrogel to the ocular surface.
The clear corneal incision (CCI) is arguably the most popular wound construction technique for modern cataract surgery. Preferred for their self-sealing properties, CCIs avoid induced astigmatism and excessive bleeding in the majority of cases. I typically construct a CCI and use a liquid ocular bandage for added protection.

Of the two hydrogel liquid ocular bandages commercially available in Europe, I use OcuSeal (Beaver-Visitec International, Ltd., Oxfordshire, United Kingdom; Figure 1) to ensure safe closure of CCIs after cataract surgery. Within 20 seconds of applying OcuSeal to the ocular surface, the crosslinked liquid forms a smooth and transparent barrier to protect the corneal incision from microbial infection, allowing the incision to heal and possibly providing added protection from endophthalmitis. The bandage, undetectable by slit-lamp evaluation just hours after application, lasts for 1 to 2 days. It degrades and disappears from the incision site within 4 days, coinciding with recovery of the epithelium and formation of new tissue at the wound site.

OcuSeal is supplied as two components, a powder polyethylene glycol and a liquid polyethylene amine. When mixed and shaken for 5 seconds, they form the hydrogel bandage. This bandage can then be applied directly to the ocular surface.

TIPS

For a video demonstration of the use of OcuSeal, visit http://eyetube.net/?v=nenik. There is a short learning curve associated with the use of OcuSeal. I noticed some difficulty in applying the bandage quickly enough. Because OcuSeal polymerizes in 15 seconds, it is imperative that application occurs as soon after the two components are mixed as possible to avoid a surplus of OcuSeal on the wound.

Another hiccup can occur if too much OcuSeal is applied to the ocular surface, which can result in mild foreign body sensation immediately after surgery. (This event was mainly due to the learning curve associated with the proper mixing time.) However, in most cases the patient’s eye blinking is enough to remove the excess within 12 hours after application. If too much OcuSeal is applied, it is possible to remove the surplus immediately with a sponge and start again with a new application.

CLINICAL EVALUATION

We recently conducted a study of 123 eyes (91 patients) in which the OcuSeal hydrogel liquid bandage was applied to the CCI of one or both eyes at the end of routine cataract surgery. The incision size was approximately 2.8 mm in most cases. When we implanted the Synchrony IOL (Abbott Medical Optics Inc., Santa Ana, California), we enlarged the incision to 3.75 mm. There were no adverse events, and the sealed wound appeared to increase patient comfort, with only 15% of patients reporting foreign-body sensation 1 day after surgery. However, in the 63 eyes that had unilateral application, 70% reported foreign-body sensation in the eye without OcuSeal. These results are based on the fact that any corneal incision creates some amount of damage to the epithelium. Additionally, it appears that applying OcuSeal to the wound blocks the CCI from letting infectious bacteria into the eye, thus decreasing the risk for endophthalmitis.

Matteo Piovella, MD, is Director of the Centro di Microchirurgia Ambulatoriale, Monza, Italy. Dr. Piovella states that he is a consultant to Abbott Medical Optics, Inc., and Beaver-Visitec International. He may be reached at tel: +39 039 389 498; e-mail: piovella@piovella.com.
Tip No. 2: Use only enough hydrogel to cover the incision. The hydrogel adheres to the ocular surface according to how much epithelial damage surrounds the wound. With more expansive epithelial damage, selective and prolonged adherence can last up to 2 weeks, thus eliminating the need for multiple layers of hydrogel. Avoid applying excess hydrogel, as too much material can create a protuberance and lead to foreign body sensation.

**IMPROVING WOUND INTEGRITY**

Wound integrity of clear corneal incisions (CCIs) can be compromised in the first few hours after surgery by deforming forces such as removal of the lid speculum, sneezing, and squeezing or rubbing the eye. Resulting changes in intraocular pressure (IOP) can lead to leakage and hypotony, which can trigger further complications. Additionally, a suction effect as the anterior chamber attempts to maintain a stable IOP can result in ingress of fluid from the tear film—a significant risk factor for endophthalmitis.

I recently tracked the wound architecture and healing pattern of CCIs with (n=22) and without (n=23) the use of the ReSure hydrogel bandage. Within 2 hours of surgery...
and at 24 hours and 7 days after surgery, optical coherence tomography (OCT) images were obtained. CCIIs with the hydrogel bandage had relatively higher IOP than CCIIs in the control group (19.4 ±5.94 mm Hg vs 13.4 ±5.28 mm Hg; \( P < .001 \)). Microleaks captured under the hydrogel at the external lip of the wound could also be observed (Figure 3). This finding suggests that microleaks, difficult to detect with Seidel test but clearly visible as a bleb of fluid beneath the hydrogel,\(^2\) may be more common than previously thought. Because they can lead to a decrease in IOP following surgery, microleaks can cause internal endothelial wound gape and other wound complications.

**CONCLUSION**

Hydrogel bandages form a smooth in-line profile to cover areas of epithelial damage with the appearance of pseudoepithelium (Figures 4 and 5). They improve patient comfort, particularly in the first few days following surgery, and in the majority of eyes they are gone by 1 week after surgery as they are gradually replaced by healing tissue.

The ReSure hydrogel bandage is a useful adjunct in cataract surgery, especially if the quality of the wound architecture is questionable, such as those created by a junior surgeon in training or when the wound is too short or steep. Higher-risk patients—those with diabetes, those who have had previous vitreoretinal or glaucoma surgery, and those in whom premium IOLs (toric or multifocal) are being implanted, where the lens will require good stability in the capsular bag—would also benefit from the added protection of a hydrogel bandage.

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Daniel Calladine, MRCOphth, BMBS, BMedSci, is a Registrar Ophthalmologist in the Oxford Deanery, United Kingdom. He is also a postgraduate research student with Nottingham and Reading Universities, investigating new applications for hydrogels in ophthalmology. Mr. Calladine states that he has no financial interests in the products or companies mentioned. He may be reached at e-mail: drdancalladine@doctors.org.uk.

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**TAKE-HOME MESSAGE**

- Hydrogel bandages form a smooth in-line profile to cover areas of epithelial damage.
- These bandages are a useful adjunct in cataract surgery, especially when the wound architecture is questionable.
- Ocular bandages are gradually replaced by healing tissue and are usually gone from the eye by 1 week after surgery.