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Novel Adhesive Biomaterials for Quick and Long-Lasting Sutureless Repair of Corneal Injuries

Principal Investigator: DANA, REZA

Institution Receiving Award: SCHEPENS EYE RESEARCH INSTITUTE

Program: VRP

Proposal Number: VR170189

Award Number: W81XWH-18-1-0654

Funding Mechanism: Technology/Therapeutic Development Award

Partnering Awards:

Award Amount: \$2,083,571.00

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PUBLIC ABSTRACT

Objectives and Rationale of Project – The cornea is the clear dome-shaped structure that comprises the very front of the eye. Its clarity and proper shape are required for good vision. Injuries that lead to tissue loss, deep cuts (lacerations), or corneal thinning can lead to poor vision and often jeopardize the entire eye. When severe, these injuries require surgical intervention with sutures or grafts (where tissue is applied to the corneal defect) to provide structural support and to re-establish near-normal corneal contour for restoration of vision. However, these procedures are associated with substantial drawbacks: (1) access to specialized equipment, supplies, and subspecialty care, which are often not immediately available; (2) corneal sutures often induce optical irregularities that impede vision; and (3) corneal grafting requires eye bank tissue, which is often not immediately available.

When primary surgical correction is not feasible, adhesives such as cyanoacrylate glue ("Krazy glue") are applied to the cornea as a temporizing measure to treat or prevent a perforation or impending-perforation. But cyanoacrylate glue has many limitations: it is toxic to healthy tissue, induces inflammation, has a rough texture that cannot be tolerated and requires a bandage contact lens, and its application is difficult to control. Alternative corneal adhesives, such as the recently approved ReSure® sealant have other significant limitations: they cannot be applied in the field setting, require a microsurgical theater, and cannot be used to fill corneal defects.

To address the shortcomings of the current technologies, we have launched a multidisciplinary team between ophthalmic and bioengineering investigators in Boston to develop smooth, transparent, biocompatible, and potent adhesives that could not only bond corneal tissues for closure of lacerations, but could also fill in corneal defects, would be easy to apply, and would be retained for long periods so that it could potentially even replace corneal tissue. Our synthetic gel-derived bioadhesives have been extensively tested on eyeballs (outside the living body) and have shown prolonged retention even when filling in large tissue gaps. The objectives of our proposed research program are to optimize the mechanical and adhesive properties of the GelMA-based bioadhesives that we have developed so that we will be ready to take the technology into the clinic for applications in humans in the next phase of its development.

Applicability and Potential Impact for Military and Civilian Populations – Ocular trauma is a common cause of vision loss in the general population, and even more so among United States Warfighters – ocular trauma accounted for 13% of all body injuries in the Operations Iraqi Freedom and Enduring Freedom. Corneal injury, in particular, is very common among active duty and combat personnel: in Operation Iraqi Freedom, 12% of eye injuries involved lacerations of the front of the eye. The costs of eye injuries in the military from 2000 to 2010 were in excess of \$2 billion per year. Often, the most critical factor determining visual prognosis in serious ocular trauma is how quickly these injuries are repaired, with repairs requiring (i) advanced surgical skills and equipment and (ii) warfighter evacuation to specialty surgical centers. A safe technology that can seal the eyeball, fill structural defects in the cornea, and remain transparent while being retained for prolonged periods without use of sutures or bandage contact lenses would be a significant sight-saving technology for ocular injured Warfighters.

In addition to combat, projectile and improvised explosive device-related ocular injuries, millions of other Americans lose vision from physical trauma, chemical injuries, and severe inflammatory conditions (such as from corneal infections) that lead to corneal thinning and, in severe cases, near-perforations. In all these cases, a smooth and clear-transparent biomaterial that can fill defects, bond tissue, and restore structural integrity to the eye quickly and with minimal additional technology other than a light source can be a true disruptive technology that changes the landscape of ophthalmic surgery.

Projected Timeline for Achieving Expected Outcomes – We have two clearly defined goals for this 3-year period: (1) to optimize the mechanical and adhesive properties of our GelMA-based bioadhesive so that it replicates the structure of the cornea as closely as possible, and to evaluate its capacity to fill stromal defects and integrate with the corneal tissue, and (2) to combine our GelMA-based bioadhesive with different concentrations of PEGDA to improve its adhesion and ability to seal corneal lacerations without

using sutures. Our goals are well defined, feasible, and within the expertise of our respective laboratories.

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