Creation and validation of a simulator for corneal rust ring removal

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ABSTRACT ●

Purpose: To create and validate a simulation model for corneal rust ring removal.

Methods: Rust rings were created on cadaveric eyes with the use of small particles of metal. The eyes were mounted on suction plates at slit lamps and the trainees practiced rust ring removal. An inexperienced cohort of medical students and first year ophthalmology residents (n=11), and an experienced cohort of senior residents and faculty (n=11) removed the rust rings from the eyes with the use of a burr. Rust ring removal was evaluated based on removal time, percentage of rust removed and incidence of corneal perforation. A survey was administered to participants to determine face validity.

Results: Time for rust ring removal was longer in the inexperienced group at 187±93 seconds (range of 66-408 seconds), compared to the experienced group at 117±54 seconds (range of 55-240 seconds) (p=0.046). Removal speed was similar between groups, at 4847±4355 pixels/minute and 7206±5181 pixels/minute in the inexperienced and experienced groups, respectively (p=0.26). Removal percentage values were similar between groups, at 61±15% and 69±18% (p=0.38). There were no corneal perforations. 100% (22/22) of survey respondents believed the simulator would be a valuable practice tool, and 89% (17/19) felt the simulation was a valid representation of the clinical correlate.

Conclusion: The corneal rust ring simulator presented here is a valid training tool that could be used by early trainees to gain greater comfort level before attempting rust ring removal on a live patient.

Corneal rust rings are common presenting problems to family physicians, emergency doctors, and ophthalmologists. Rust rings develop when an iron-containing metallic foreign body is embedded in the cornea and reacts with the tear film.[1] This is a common occurrence in patients who have been doing metal-on-metal work. The iron becomes oxidized after remaining in contact with the cornea, which allows it to diffuse into the corneal stroma. Immune cells subsequently migrate to the iron, and the clinical rust ring forms.[2]

Leaving a corneal rust ring in place may lead to infection, scarring, neovascularization, necrosis, and ultimately loss of vision.[3,4] Removal of corneal rust rings is thus an important skill to master, yet one that primary care physicians and beginning ophthalmologists often find intimidating.

Simulation models are becoming the standard for surgical teaching of medical residents.[5,6] Simulation programs for cataract surgery and other ophthalmic techniques have been reported in the literature.[7–9] There have, however, been no reports in the literature of models for rust ring simulation that use cadaveric human corneal tissue. One model has been described that involves dipping a paper clip into a rust-colored crayon and then submerging it in paraffin,[10] whereas another model uses cardboard as a substitute for the cornea.[11] What appears to be the most elaborate model made use of a porcine eye for emergency room physician training; however, the details of this model were not elucidated in the paper, and no attempt was made to validate the model.[12]

The goal of this project is to create and validate a reliable simulation model for corneal rust ring removal. By creating such a model, beginning ophthalmology residents and primary care physicians can practice this skill in a low-stakes environment in order to become more comfortable performing it independently on a patient.

METHODS

This study consisted of 2 parts: the creation of a reliable model to simulate rust ring removal on a cadaveric eye (part 1), and a prospective validation study of the eye model to be used in training (part 2). The study adhered to the tenets of the Declaration of Helsinki, and ethics approval was obtained from the Queen's University and Affiliated Teaching Hospitals Health Sciences Research Ethics Board.

Part 1: Model Creation

Frozen cadaveric eyes were obtained from The Eye Bank of Canada, Ontario Division, and used within 3 days of thawing. Eyes older than 3 days were not used because these often perforated on attempted rust ring removal. Although several methods were explored in an attempt to create the most authentic-looking rust ring on the cadaveric eyes, we describe the technique found to be most effective.

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Iron particles of approximately 0.5–1.0 mm were collected from an automotive mechanic. These metal particles were placed on the surface of a cadaver cornea and left exposed to room-temperature air for approximately 1–2 hours. Between the 1- and 2-hour marks, the eyes were examined under an operating room microscope to assess the degree of rust ring formation. If an adequate rust ring had formed, the metal particle was removed; if the rust ring was still developing, then the metal particle was left to oxidize for longer. A high-magnification photograph of a sample rust ring created with this technique is shown (Fig. 1).

After the creation of the rust ring, the cadaveric eye was mounted on an ocular suction plate (Mastel Precision Ophthalmic Surgical Instruments, Rapid City, SD), and suction was applied to fix the eye in position. To enhance the firmness of the eye and maintain suction, a 30-gauge needle was used to inject water into the vitreous cavity until the eye was deemed to be firm by the study investigator (approximately 80 mm Hg by Tono-Pen; Reichert Technologies, Reichert, Inc, Depew, NY). The suction plate with the fixated eye was then mounted on a slit lamp such that a trainee could perform rust ring removal, as he or she would in a clinical setting. For the purposes of this study, the slit lamp we used had digital photograph capabilities (Fig. 2).

Fig. 2—A cadaveric eye secured on a suction plate that is anchored to the slit lamp, allowing a trainee to attempt rust ring removal.

Part 2: Model Validation

To validate the above model, a convenience sample of medical students, ophthalmology residents, and ophthalmology faculty at Queen's University (Kingston, Ont.) was used to trial the rust ring simulator. Residents and faculty in the ophthalmology department were approached on January 15, 2016, the day of testing, and included if they were available to participate. Medical students known to be interested in ophthalmology and who felt proficient with the slit lamp were asked if they would like to participate.

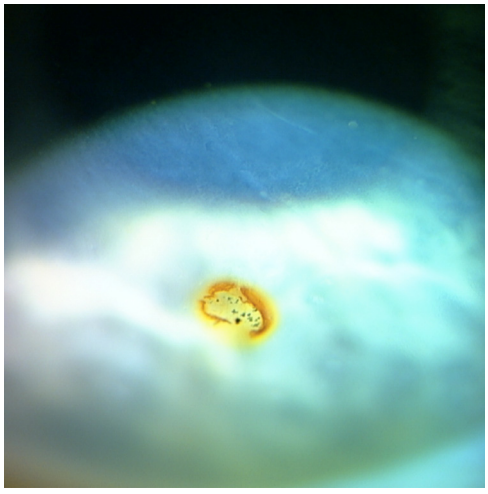

Fig. 1—Example of a rust ring formed by allowing a metal particle to rest on a cadaveric cornea for approximately 1 hour.

Medical students and first-year residents were grouped together as the inexperienced cohort, whereas second-year residents and their seniors were grouped as the experienced cohort. This stratification was based on the structure in the Queen's University Ophthalmology program, in which it is typical that trainees would not gain comfort-with, if any exposure at all, rust ring removal until second-year residency.

Participants were asked to complete a questionnaire documenting their experience with rust ring removal with a burr, before rust ring removal. Specifically, they were asked whether they had ever removed a rust ring using a burr and how many rust rings they had removed in the past year.

Participants were instructed that the success of their rust ring removal would be evaluated based on 4 parameters:

1. *Time to remove the rust ring:* The goal was to remove the rust ring as quickly as possible, while taking into account the other parameters on which they were being assessed.

2. *Amount of remnant rust:* Participants were advised to remove as much rust as they deemed possible, while taking care to stay safe and avoid rupturing the globe by penetrating too deeply.

3. *Extent of corneal surface area damage relative to rust ring surface area:* Participants were told to mind of any