Device for simulating anterior segment surgery

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To provide a more realistic method for practicing anterior segment surgery, a device was designed that incorporates aspects of currently available cadaver globe fixation methods. A Styrofoam head was fitted with a funnel and tubing system that allows for direct application of variable external suction to a globe placed in an artificial socket. Prototypes were tested in a wet lab environment, which demonstrated that this method provides reliable globe fixation and allows for variable control of intraocular pressure during a variety of anterior and posterior segment surgical techniques.

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An integral part of performing surgical procedures on human patients is having adequate laboratory experience so as to become reasonably familiar with the anatomy and instruments involved. This is especially true with ophthalmologic surgery, in which there is an exquisitely small tolerance for error. Surgical practice for beginning ophthalmology surgeons is usually obtained through the use of sacrificed livestock or harvested animal and human eyes that can be secured beneath an operating microscope using a variety of methods. In ophthalmology residency programs, animal or cadaver eyes are typically placed in a hollowed-out eye socket of a Styrofoam head and secured by pins or sutures. At demonstrations at ophthalmology conferences, eyes are usually held in place in a flat plastic base, to which static vacuum is applied. Both these methods have inherent shortcomings, and it was felt that a new method of securing globes, 1 that combined the anatomic features of a Styrofoam head with the vacuum concept of a plastic base, could provide improved simulation of anterior segment surgery.

Surgical Technique

A prototype was constructed from a Styrofoam mannequin head into which a plastic tubing system was inserted (Figure 1). First, a medium-sized standard plastic funnel was cut parallel to its opening to make the funnel mouth about the same size as the external ocular surface on 1 side of the Styrofoam head. The spout portion of the funnel was also cut to approximately half its original length. A hot soldering iron was then used to sculpt an orbital cavity on only 1 side, being careful to make the external opening about the same size as the outer edge of the funnel mouth. The orbital cavity was extended posteriorly to allow sufficient space for insertion of a 90-degree elbow and plastic tubing. The orbital cavity was also connected with a central cavity that runs through the neck of the Styrofoam head, which was created during the original Styrofoam manufacturing process. This central cavity was also enlarged with the soldering iron to allow insertion of plastic tubing.

The internal tubing system of this device consists of the modified funnel, a 90-degree plastic elbow with an outer diameter of 1/2 inch on both ends, a plastic suction adapter with an external diameter of 1/2 inch on one end and 1/4 inch on the other, and 2 different

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lengths of 1/2 inch internal diameter plastic tubing. The spout end of the funnel was inserted snuggly into 1 end of a 1-inch length of plastic tubing. The other end of this short piece of tubing was fitted over 1 end of the 90-degree plastic elbow. The second length of plastic tubing, 8 inches in length, was then fitted over the other end of the elbow. Finally, the 1/2-inch end of the suction adapter was inserted into the open end of the 8-inch long tubing.

This entire funnel-tubing apparatus was then fed through the orbital opening in the Styrofoam head, adapter end first, so that the funnel rested flush with the orbital opening and the suction adapter protruded from the circular opening in the base of the head. As the tubing apparatus was inserted into the head, the orbital cavity was filled part way with silicone sealant to help fixate the elbow within the head. Once the tubing was fed all the way into the base of the head, the funnel was brought into proper position at the opening of the orbital cavity. Additional silicone sealant was then applied around the outer edge of the funnel to fixate the funnel within the orbit and to eliminate any space between the outer edge of the funnel and the anterior edge of the orbital cavity. If the orbital cavity and outer funnel diameter were properly sized, the tubing system could be left in place and the silicone sealant allowed to dry without further manipulation of the tubing or funnel. After the sealant harded, additional silicone sealant was applied around the adapter end of the tubing where it exited from the base of the head. Once this area was completely dry, the device was ready for use.

Three such prototypes were constructed, and each was taped into the headrest of a surgical eye bed in the standard surgical position (Figure 2). Three workstations were then assembled, including 2 for the practice of phacoemulsification and 1 for pars plana vitrectomy. For each participant, the suction adapter end of the device was attached to a wall-mounted operating room vacuum unit by means of standard suction tubing. The strength of the vacuum was set to its lowest level by adjusting the control valve on the unit. A pig eye was then placed in the funnel of the device, optic nerve side down, and external vacuum was slowly increased. The practitioner sat by the device and assessed the fixation and firmness of the globe as the strength of the suction was increased. When the proper degree of globe stabilization and intraocular pressure (IOP) was achieved, the surgeon notified the technician to stop increasing vacuum. The device was then ready for surgical practice, and if suction was lost during use, or if a different level of globe firmness was desired, this process of adjusting vacuum was repeated.

Results

This device provided adequate globe fixation in all instances. In cases in which insufficient vacuum was initially applied, it became immediately obvious that the globe had not been properly secured and additional vacuum was applied until the desired amount of stabilization was achieved. The adnexal tissue that typically accompanies animal globes provided a ring of

Figure 1. Modified Styrofoam head and vacuum tubing components of the device.

Figure 2. Device secured to a headrest with the cadaver globe in place.

periocular tissue that allowed for proper suction to be easily achieved. After the necessary suction was established, the strength of the external vacuum could also be varied depending on whether the practitioner wanted a softer or firmer globe. Changes in the strength of the externally applied vacuum seemed to correlate directly with changes in IOP. In 1 instance, while 1 of the residents was practicing phacoemulsification, the external vacuum was inadvertently raised to near maximum levels. With the sudden increase in a dynamic situation was created in which the vitreous, lens, and iris were pushed anteriorly in a fashion very similar to an acute suprachoroidal hemorrhage, giving the resident exposure to what this might be like in a real-life situation. One device was also used by 1 of our retina staff to test a new 25-gauge vitrectomy handpiece. While the external vacuum had to be decreased to provide more realistic simulation of intraoperative IOP, the retina surgeon was able to successfully use this device to gain familiarity with the positioning and flexibility of the new 25-gauge instrument.

Discussion

This device provides a consistent and reproducible method for securing a globe during the practice of anterior segment surgery. The combination of a Styrofoam surface that simulates the human head with variable external suction provides a more realistic means of practicing ophthalmologic surgery than previous methods. The ability to control IOP also makes this method well suited for the practice of posterior segment surgical techniques. This device could play an important role in the education of ophthalmology surgeons who desire a more realistic environment in which to gain additional practice with new surgical techniques and instrumentation. While there have been descriptions of computerized systems for simulating ocular surgery,[1,2] there have been no reports in the literature of devices for securing a globe in the wet-lab environment. Until virtual ocular surgery becomes widespread and cost effective, the device described here offers a safe and economical means for ophthalmology residents and veteran surgeons to refine their skills and improve their familiarity with new instrumentation prior to using them in human patients.

References

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