

Formalin-assisted training eyes for ophthalmic wet lab practice

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The foundation of an ophthalmologists' microsurgical career begins in the wet lab. Training on donor cadaveric, animal like goat or pig eyes provide the most realistic surgical environment, however, the availability of a donor's eyes for practice is limited. This scarcity is further escalated in this current coronavirus disease 2019 pandemic where eye donations have decreased. Even among those eyes which find their way into the wet lab, quite a few would have collapsed significantly making training difficult. Therefore, we looked at ways to salvage these collapsed globes. We describe a novel way of salvaging the collapsed eyeballs by injecting formalin in slow boluses into the vitreous cavity. The longer maintenance of the globe integrity without necessitating repeated injections facilitates better quality of surgical training and optimal utilization of these eyes.

Key words: Animal eye, cadaver eye, formalin, surgical training, wet lab

Surgical skill training in ophthalmology is a complex time-consuming process involving a significant time being spent in the wet lab. There are various new 3D models and virtual reality devices which aid in training, but currently, these have not attained a status to be considered as equivalent substitutes to training on cadaveric or animal eyes. Moreover, simulators are cost-prohibitive and difficult to maintain because of the annual maintenance contract expenses and the software upgrades that would be required. Data suggest that the total number of corneas donated in India is approximately 25,000 per year and the utilization rate of the donor's eyes is over 50%.^[1,2] So, the number of human eyes available for training is substantially less. In the current coronavirus disease 2019 (COVID-19) pandemic, the number of eye donations has also reduced significantly leaving the trainees with little options but to train with goat or pig eyes. Practicing steps like creation of a scleral tunnel or raising a flap needs a very firm globe. The limiting issue with the use of cadaveric or animal eyes is the quality of the eyes. Quite a lot of eyes would have collapsed to an extent that training with those eyes would not be possible. We have identified a new simple technique to salvage a collapsed eyeball, make it tense, and thereafter, use for training purpose providing a near-physiological environment.

Technique

Approval was obtained from our Institutional Ethics Committee to use cadaveric eyes and goat's eyes for research purposes. This

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research adhered to the tenets of the Declaration of Helsinki. Collapsed cadaveric eyeballs which were deemed unsuitable for use in transplantation and goat's eyes were used. The human eyes that were suitable for wet lab use were stored in a refrigerator in our eye bank and were used within 36 hours of death. The goats' eyes were sourced from the local butcher shop the same morning of their death, stored in an icebox in the wet lab, and used the same day.

The innovation involves an injection of approximately 1.0 mL formalin into the vitreous cavity trans-sclerally using a 23- or a 26-G needle inserted obliquely. Formalin seems to give a solidifying effect inside the vitreous cavity, and therefore, it does not leak out quickly. This increases the intraocular pressure (IOP) and keeps the eyeball tense for a longer duration and makes it ideal for training.

For the purpose of illustration, we have used goat's eyes of similar sizes. All the eyes were soft but with no evidence of scleral dehiscence. They were placed upright on a holder. The initial IOP could not be measured since the globe was collapsed. We injected the three eyes with saline, formalin, and viscoelastics (hydroxy-propyl-methyl cellulose, HPMC) respectively using a 23-G needle fitted on a 1-cc or 2-cc syringe. The saline was injected using a 2-cc syringe whereas formalin or viscoelastics was injected using a 1-cc syringe fitted with a 23-G needle. Fluid was injected in slow boluses till the globe became firm and injection was stopped with the earliest

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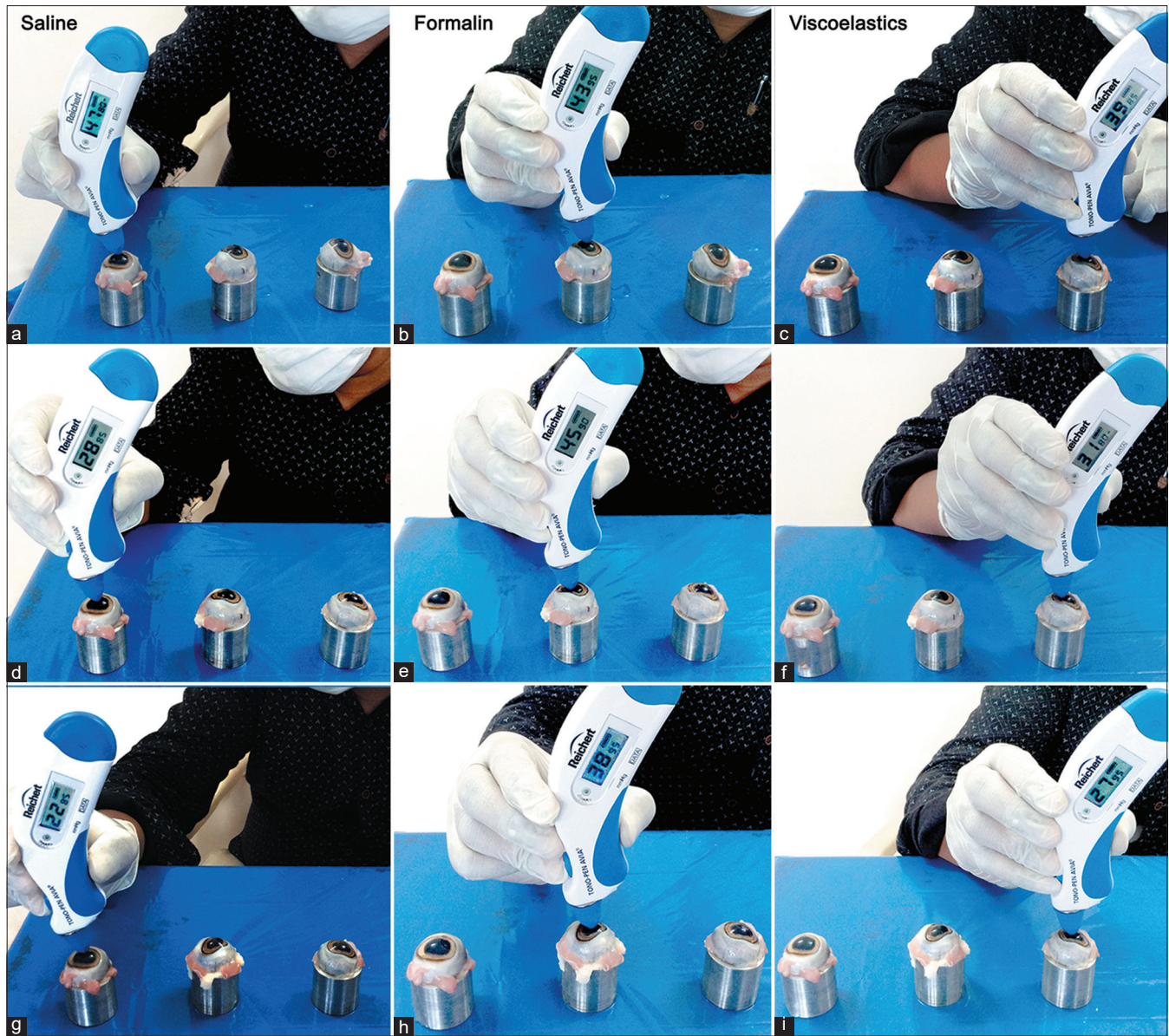


Figure 1: (a–c) Intraocular pressure (IOP) measurement using a Tonopen immediately after injection (d–f) IOP measurement 5 min after injection (g–i) IOP measurement 15 min after injection

compromise of corneal clarity. This was only to make sure that all eyes were tense to the same extent, however, for practical wet lab purposes, the injection can be stopped just before the development of corneal edema if the globe is tense enough. The amount of solution required to make the globe firm is variable depending on the size of the globe and the degree of collapse. The quantity of saline (1.5–2.0 mL) that was needed to be injected was always more than that of formalin (0.6–1.2 mL) or viscoelastics (0.6–1.2 mL). Here, we needed to inject 1.8 mL of saline, 0.8 mL of formalin, and 0.8 mL of HPMC. We then evaluated the IOP using a Tonopen (Reichert, Depew, NY, USA) immediately after injection, 5 min later, and then at 15 min. The median of three readings in each eye was noted at each point of time [Fig. 1].

Under observational conditions, we found that the IOP was well maintained with the use of formalin than with

viscoelastics or saline [Fig. 2]. Furthermore, when any training procedure was performed, this difference was exaggerated since the saline tends to leak out faster when pressure is applied on the globe more than viscoelastics which in turn leaks faster than formalin. With either of the solutions, the pressure was not too high to spray fluid when the anterior chamber was entered. Having said that, it is always safer to use gloves and protective glasses for any procedure.

Due to the viscous nature of viscoelastics, it is not possible to inject it via a 26-G needle, whereas formalin can be injected through it leading to a smaller puncture in the sclera, and consequently, even lesser leakage. External procedures like creating a tunnel, fashioning a scleral flap, and suturing can be performed similar to that in live eyes [Fig. 3]. Multiple tunnels or flaps can be made on a single eyeball. Formalin works similarly well for internal procedures also; however, once the

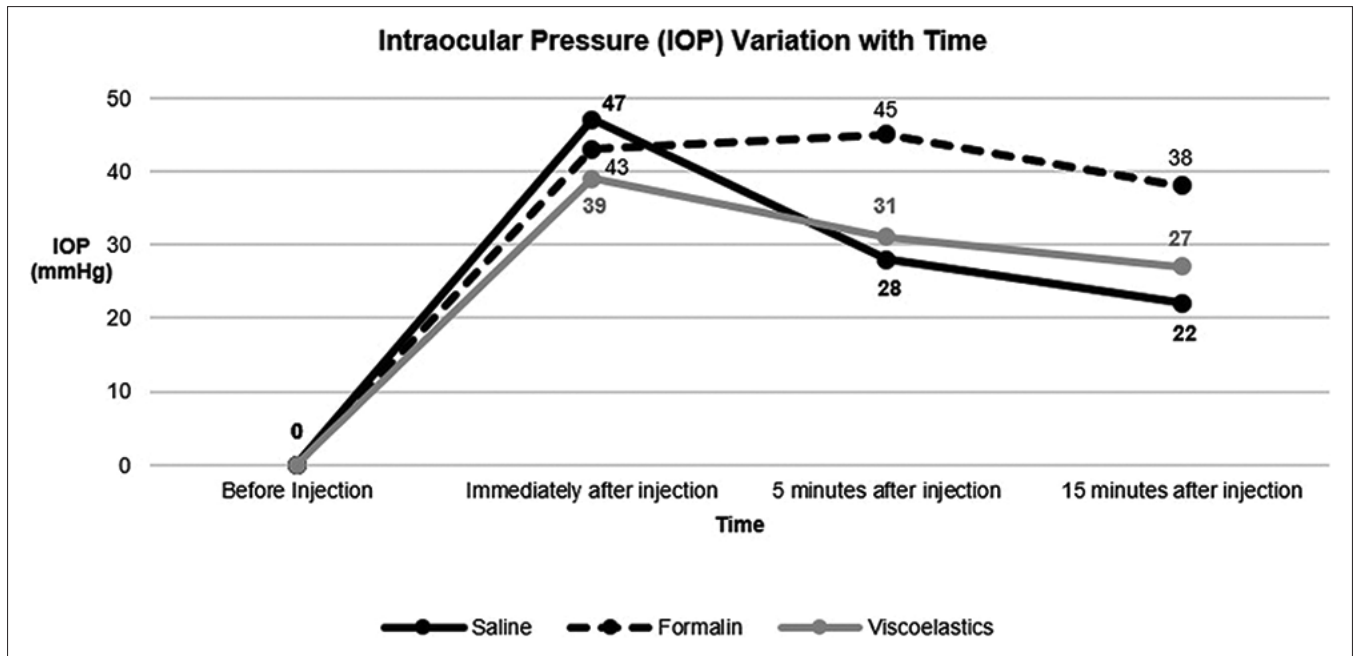


Figure 2: Graph showing the intraocular pressure variations with time after injection of the solution in a goat's eye

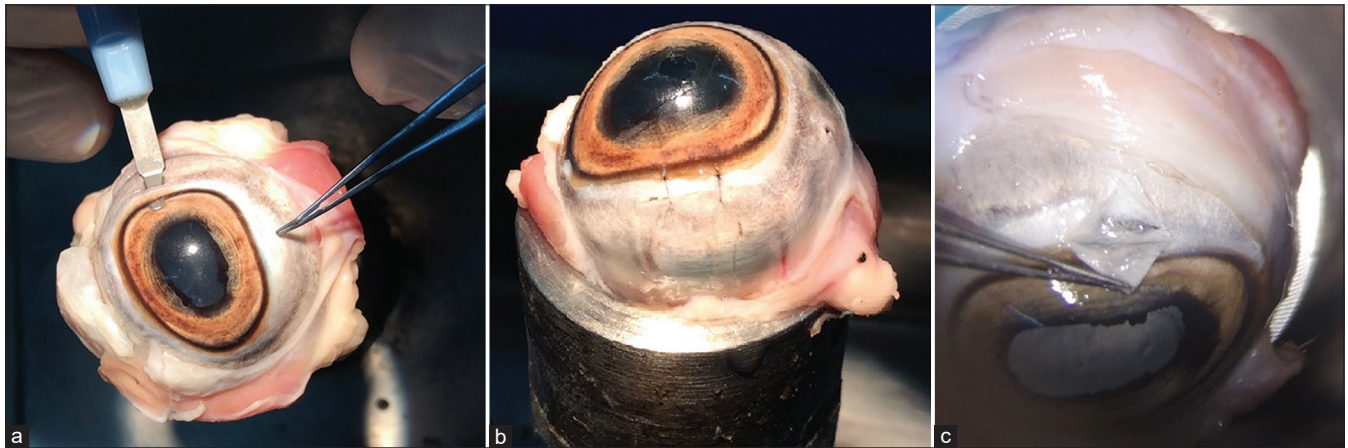


Figure 3: Performance of various surgical steps in formalin-filled goats' eyes. (a) Scleral tunnel (b) Suturing (c) Scleral flap

anterior chamber is entered, the aqueous humor gets expelled. Any intraocular training procedure like capsulorrhexis and phacoemulsification needs a well-formed anterior chamber for which viscoelastics may be needed.

Discussion

Using this technique, we were able to salvage a lot of collapsed eyeballs and perform good-quality training in such eyes. Our innovation helps maintain a firm eyeball during training. In addition, to maintain stability, we may fix the globe with the Spring-action Apparatus for Fixation of Eyeball (SAFE)^[3] or use pins and fabric.

Various new innovations and devices have become available in the recent past to simulate a live surgical environment like the use of microwave to induce cataract in animal eyes,^[4] the insertion of human cataractous lens into the animal eyes,^[5] 3D printed eye models and the virtual

reality models.^[6,7] Use of the artificial devices, however, does not simulate a live scenario and surgeon anxiety is negated. Conventionally, surgical training involves the use of cadaveric or animal eyes like that of a goat and pig. It still provides the closest environment to live surgery. The problems faced with using these eyes are that the eyeball may have collapsed and there is no positive vitreous pressure that is seen in live eyes. Various materials like the injection of saline or use of residual viscoelastics that was available at the end of the day after surgery have been tried to maintain the integrity of the globe, but we found that the tension did not last long enough, and these tend to leak out through the same needle entry necessitating repeated injections. Multiple entries lead to progressively increasing leakage as well. This leakage and consequent loss of integrity is much less with the use of formalin. Additionally, we also noted that the cost of formalin was negligible with 1 mL costing around Rs. 0.30 (0.004 USD) only.

Formalin is the disinfectant solution used for sterilization of the operating rooms. It is a 37% aqueous solution of formaldehyde used for fumigation; 50 mL of formalin is used in 1:1 dilution, poured into the fumigator, and placed for 20 min in the operating room during fumigation. Additionally, formalin is used to induce cataracts and make the anterior lens capsule less elastic in goat eyes for surgical training.^[8] Formalin is also a widely used fixative in cellular pathology. Approximately, 1.0 mL of the same solution is used for our purpose by injecting it into the vitreous cavity without any dilution. Probably, the eyeball is fixed at least partially by the injection of formalin, which leads to its higher stability as compared to methyl cellulose and saline. At this volume, we do not see any side effects like pungent smell or symptoms of irritation that we commonly come across after fumigation. The amount of formalin injected can also be titrated depending on the firmness of the globe. We have performed the same in human cadaveric eyes and the results are similar.

Conclusion

In conclusion, we find that though this innovation seems very trivial, its efficiency is remarkable in maintaining the firmness of the globe, thereby, improving the training experience. Considering the low availability of cadaveric eyes, it is in the best interests of the trainee that whatever eyes are available need to be salvaged and used to the maximum.

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Conflicts of interest

There are no conflicts of interest.

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