

# Redrawing vitreoretinal surgical training program in the COVID-19 era: Experiences of a tertiary care institute in North India

Ramandeep Singh, Atul Arora, Basavaraj Tigari, Simar Rajan Singh, Mohit Dogra, Deeksha Katoch, Reema Bansal, Vishali Gupta

**Purpose:** The COVID-19 pandemic has brought medical and surgical training to a standstill across the medical sub-specialties. Closure of outpatient services and postponement of elective surgical procedures have dried up opportunities for training vitreoretinal trainees across the country. This “loss” has adversely impacted trainees’ morale and mental health, leading to feelings of uncertainty and anxiety. Therefore, there is an urgent need to redraw the surgical training program. We aimed to describe a systematic stepwise approach to vitreoretinal surgical training. **Methods:** We introduced a three-pronged approach to vitreoretinal surgical training comprising learn from home, wet lab and simulator training, and hands-on transfer of surgical skills in the operating room in our institute. **Results:** Encouraging results were obtained as evaluated by feedback from the trainees about the usefulness of this three-pronged approach in developing surgical skills and building their confidence. **Conclusion:** The disruption caused by the COVID-19 global pandemic should be used as an opportunity to evolve and reformulate surgical training programs to produce competent vitreoretinal surgeons of the future.

**Key words:** Resident training, simulator training, vitreoretinal surgery, wet lab training

The coronavirus (COVID-19) pandemic has caused global disruption in many sectors, including world economics, education, and lifestyle. The healthcare system also has witnessed an unprecedented impact. All healthcare resources have been channelized to meet the massive demand that this global health crisis has placed on it. Routine services such as outpatient clinics, diagnostics, and office procedures across all subspecialties have been postponed to reduce COVID-19 transmission risk.<sup>[1,2]</sup> About 28 million elective surgical cases were cancelled or delayed worldwide during the first wave of the pandemic in early 2020.<sup>[3]</sup> Furthermore, to minimize operative time and the risk of COVID-19 transmission intraoperatively, senior surgeons are now performing more of the emergency cases, and training opportunities are further reduced.<sup>[4]</sup>

Similarly, in ophthalmology, priorities have shifted from non-urgent elective ocular surgeries to managing ophthalmic emergencies.<sup>[5,6]</sup> All these factors have negatively impacted surgical training and the mental wellbeing of trainees. In current times, there is a need to move away from traditional models of surgical training to ensure trainees are competent and well supported. The pandemic challenges have led to innovative developments expanding the role of simulation, wet labs, and virtual conferences in ophthalmology. In this article, we describe a three-pronged approach to vitreoretinal surgical training comprising of learn from home, wet lab and simulator training, and hands-on transfer of surgical skills in the operating room that we adopted in our tertiary

care institute to impart surgical training to our trainees. A systematic stepwise approach beginning with learning the basics of vitreoretinal (VR) surgery and viewing systems at home followed by intensive wet lab and simulator training, and practicing laser photocoagulation on a 3D printed model eye followed by orderly hands-on transfer of surgical skills in the operation room (OR) enabled the trainees to acquire surgical dexterity in challenging times of pandemic.

## Redrawing Vitreoretinal Surgical Training Program

Vitreoretinal surgery demands special skills, good hand-eye coordination, and stereoscopic skills that can be mastered only through practice. Surgical technique and the surgeon’s mastery over the skills are essential determinants of surgical success. On the other hand, insufficient surgical training is associated with higher complication rates amongst inexperienced ophthalmic surgeons.<sup>[7]</sup> Trainees come from diverse backgrounds and have varied temperaments and natural surgical aptitudes. Some are naturally dexterous and learn quickly from demonstration and guidance, while some intelligent and deserving are timid with their hands and need continuous advice and support to attain competence. A well-structured and streamlined surgical training program should incorporate measures to cater to

### Access this article online

**Website:**

www.ijo.in

**DOI:**

10.4103/ijo.IJO\_2238\_21

**Quick Response Code:**

Advanced Eye Centre, Department of Ophthalmology, Post Graduate Institute of Medical Education and Research, Chandigarh, India

**Correspondence to:** Dr. Ramandeep Singh, Professor, Advanced Eye Centre, Postgraduate Institute of Medical Education and Research, Chandigarh - 160 012, India. E-mail: manko095@yahoo.com

Received: 01-Sep-2021

Revision: 16-Oct-2021

Accepted: 16-Mar-2022

Published: 28-Apr-2022

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

**For reprints contact:** WKHLRPMedknow\_reprints@wolterskluwer.com

**Cite this article as:** Singh R, Arora A, Tigari B, Singh SR, Dogra M, Katoch D, et al. Redrawing vitreoretinal surgical training program in the COVID-19 era: Experiences of a tertiary care institute in North India. Indian J Ophthalmol 2022;70:1787-93.

the diverse personalities of budding surgeons. The current pandemic and the resultant lack of training opportunities have more than ever discerned the need for a systematic surgical training program. It becomes the obligation of any surgical training program to ensure surgical competence, safety, and sound judgment in the trainees.

In our tertiary care referral center, closure of outpatient services resulted in a significant decline in elective surgeries, reducing opportunities for hands-on surgical training for the trainees. Therefore, the need was felt for reformulating the vitreoretinal surgical training program to ensure a precious training opportunity is not lost for trainees in this long-drawn-out pandemic time.

We devised a three-pronged approach to vitreoretinal surgical training [Fig. 1]. Duration and timeline of individual steps and the levels of the training program have been shown in a flowchart [Fig. 2].

### Three-Pronged Approach to Vitreoretinal Surgical Training

- A. Learn from home: Understanding and learning the basics of vitreoretinal (VR) surgery, viewing systems, etc. at home, attending surgical webinars
- B. Wet lab and simulator training, and laser photocoagulation on a 3D printed model of the eye
- C. Hands-on transfer of surgical skills in the operating room under the supervision of an experienced VR consultant.

#### A. Learn from home

Trainees were encouraged to familiarize themselves with the basic principles of VR surgery, viewing systems, etc. Due to the closure of outpatient departments (OPDs) and decrease in inpatient footfall, the spare time available to the trainees was utilized to impart basic theoretical knowledge using virtual platforms and software. Introductory online classes were organized to familiarize new joining trainees with elementary VR instrumentation, operating microscope, vitrectomy machine, basics of retinopexy, laser photocoagulation, cryopexy, and fundamental surgical principles. Surgical grand rounds were organized where surgical videos from previous surgeries by senior trainees were analyzed to discuss surgical challenges,

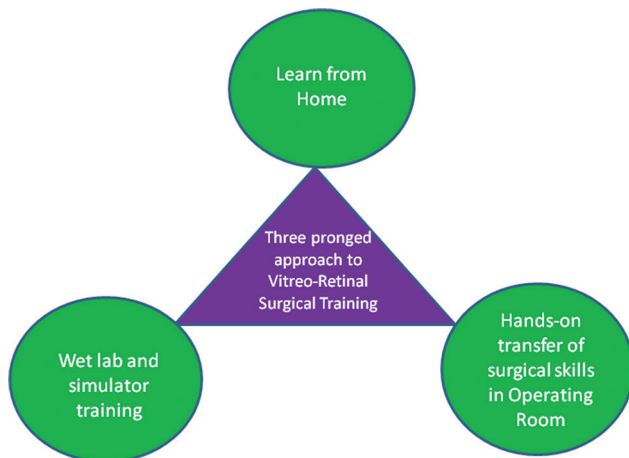


Figure 1: Schematic diagram showing three-pronged approach to vitreoretinal surgical training

different surgical techniques, intraoperative complications, and approaches to their management. Additionally, the trainees were encouraged to attend webinars on vitreoretinal surgeries to learn from the experienced faculty.

### B. Wet lab and simulator training

#### Wet lab training

A wet lab provides a safe and standardized environment for training without the risks of operating on natural eyes. Also, the same surgery can be performed multiple times without any fear of complication or failure. Repeated practice enhances hand-eye coordination, ambidexterity, and psychomotor skills of the trainee. This instills confidence in the trainee surgeon who feels better equipped to operate on a real eye.

At our center, we designated the wet lab area away from the patient care areas to minimize contact with the animal tissue. The wet lab station consisted of a vitrectomy machine, an ophthalmic microscope, and a full set of operation theatre instruments. We used goat eyes for surgical training. The anatomy of goat eyes closely resembles that of a human eye. The axial length is similar to the human eye (24.37 ± 1.16 mm). The corneal diameter is similar to that of a human's; however, horizontal diameter exceeds vertical diameter. The optics of a goat eye, thereby closely resemble the human eye. The main difference, however, is in the lens thickness. It is double in size, approximately 8 mm, in the goat eye when compared to the human eye.<sup>[8,9]</sup> In our experience, after removing the lens, the posterior segment viewing becomes clear. This makes goat eyes an ideal candidate for surgical training. Basic

Evaluation sheet		
Level 1 ( 0- 8 weeks)	Consultant signature	Date
1. Basics of VR machines, and viewing systems		
2. Online courses on simulator -VRT Vitreo-retina Basics course -VRT Dry Lab		
3. Simulator - VRT A (Introduction course)		
<b>On Goat eye under guidance</b>		
A. Suturing – Mattress suture for band and buckle		
B. Sclerotomy making – Trocar cannula, MVR		
C. Mattress suture for 20G infusion cannula		
D. Scleral tunnel/ scleral flap making		
<i>After completing both parts of level 1, resident will be allowed to go level 2</i>		
<b>Level 2 ( 9 to 16 weeks)</b>		
4. Simulator – VRT B (Beginner course)		
<b>On Goat eye under guidance</b>		
E. Practicing different techniques of trans-scleral fixated intraocular lens (TSFIOL)		
F. Lensectomy		
G. Use of contact lens		
<i>After completing both parts of level 2, resident will be allowed to go level 3</i>		
<b>Level 3 (17-26 weeks)</b>		
5. Simulator – VRT C (Advanced course)		
<b>On Goat eye under guidance</b>		
H. Core vitrectomy		
I. Posterior hyaloid removal		

Figure 2: Stepwise detail of tasks to be performed in wet lab and simulator with timeline

training of scleral buckling, that is, passing mattress sutures, applying silicon explants (with two-way/box sutures and also by creating sclera tunnels using a crescent blade), refixing of dislocated/subluxated IOLs, that is, making scleral flaps/tunnels, practicing different techniques of trans-scleral fixated intraocular lens (TSFIOL) and pars plana vitrectomy, that is, making sclerotomy ports [Fig. 3], lensectomy techniques, anterior vitrectomy, using contact lens for vitrectomy [Fig. 4], etc., were imparted under the direct supervision of senior trainees and consultants who watched and guided the junior trainees through the observer side-viewing tube of the operating microscope stationed in the wet lab. Trainees practiced each step multiple times till they felt confident in performing the task and to the satisfaction of the mentor consultant.

#### Simulator training

Surgical education uses simulation-based skills training, including 3D representations, as a critical teaching approach across most surgical specialties. This type of training is thought to boost general motivation, skill development, and skill retention. Especially when trainees' exposure to procedural skills is minimal, as in COVID-19, simulator-based education has emerged as the primary approach for training them. Deliberate practice on the simulator and their feedback are essential learning tools. It has been shown to facilitate the acquisition of surgical skills and improve patient safety profiles.<sup>[10,11]</sup> We used the EyeSi® Surgical Simulator (VRMagic, Mannheim, Germany) in which the mannequin head is used to give a natural feeling. This has a computer interface connected to a microscope with a camera, producing a virtual image both on the microscope and the touch screen. Internal sensors track the movements and positions of the surgical instruments. The trainees needed to

complete an online orientation course to familiarize themselves with the functioning of the simulator before gaining access to it. The simulator had different methods with ascending levels of difficulty (Tier A, Tier B, Tier C). Initial simulations comprised of learning steps for novice surgeons aimed to improve ambidexterity, hand-eye coordination, and psychomotor skills. Moving in a stepwise manner, the trainees practiced various tasks like posterior hyaloid detachment, peripheral vitrectomies, internal limiting membrane peeling (ILM), removal of epiretinal membranes (ERM), and treatment of retinal detachments with silicone oil or gas tamponade [Fig. 5]. Provision of scleral indentation and retinal lenses aided in experiencing a realistic simulation of different surgical steps.

Simulator training consists of different steps grouped into different levels, increasing difficulty levels as one advances from one step to another.

**Introduction course** consists of an online course where trainees learn about the different types of vitreoretinal optics, typical pitfalls for beginning retina surgeons, and the basics of posterior segment surgery.

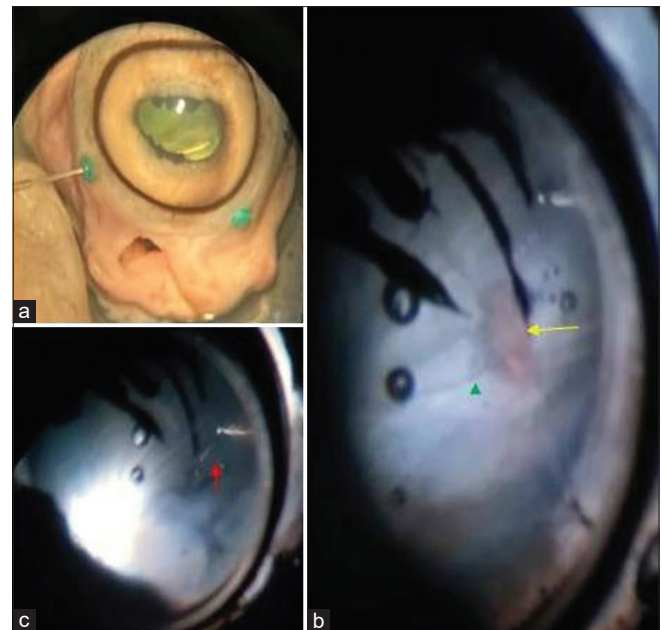
**Beginner course** consists of the following levels/steps, that is, navigation and instruments, non-dominant hand, bimanual navigation, posterior hyaloid detachment, epiretinal membrane, and internal limiting membrane peeling.

**Advanced course** consists of the following levels/steps, that is, navigation and instruments, non-dominant hand, posterior hyaloid detachment, epiretinal membrane, internal limiting membrane peeling, and retinal detachments.

Feedback on performance is pivotal in simulation training to cultivate motivation during skill acquisition. It is provided (1) automatically and immediately by the simulator software itself, (2) by the instructor giving verbal feedback during and after the training. However, an effective simulation program for



**Figure 3:** A trainee performing pars plana lensectomy and vitrectomy on goat's eye in wet lab (a) Sclerotomy ports on goat eye in wet lab (b) Intraoperative view of pars plana lensectomy being performed in goat's eye (c)



**Figure 4:** Intraoperative microscope view of pars plana lensectomy being performed in goat's eye (a) Aspiration of triamcinolone with cutter (b) Detached retina (green arrow) with iatrogenic retinal break (yellow arrow) (c)



the new setup will include both initial setup costs (microscopes, equipment) and ongoing maintenance for consumables. It might be helpful to emphasize that simulation may be a costly affair, but it enhances the trainee's skills, and gives better opportunities to acquire skills in COVID-19-like situations. Various types of feedback can be habituated to tailor the trainee's abilities and sentiments during the skill cognition process.

#### *Laser photocoagulation using a 3D printed model eye*

Laser photocoagulation (LP) involves a precise and concentrated application of high-energy light to the retinal tissue. LP has become an integral part of VR practice and is used to treat several posterior segment disorders: diabetic retinopathy, vein occlusion, retinal neovascularization secondary to occlusive vasculitis, central serous chorioretinopathy, etc. Performing LP requires skillful technique, and VR trainees should be trained for the same. The two essential skills that need to be mastered before doing retinal lasers are orientation to the inverted and laterally reversed retinal image seen through the contact lens and the ability to focus the aiming beam on the retina. The apprentice model of training has been traditionally used to teach LP to the trainees.

Shutting down of OPDs in the current pandemic restricted the opportunities for learning LP for the trainees. To overcome this, we used a 3D printed model to train our fellow trainees for performing LP. 3D printed model eye (Reti Eye, Aurolab®) is a simple, cost-effective, and reusable model eye for early training in LP.

3D printed model eye consists of two interlocking hemispheres; the upper half is printed using a flexible material: TPU (thermoplastic polyurethane). The lower half is made from plastic filament material, that is, PLA (polylactic acid). A fundus image printed on a polyethylene terephthalate glycol (PETG)

sheet gives a realistic view of the posterior segment. This sheet can be easily changed, thus allowing the same model eye to be used multiple times by various trainee surgeons. The 3D printed eye is fixed using a metallic handle upon a slit-lamp laser delivery system [Fig. 6].

The 3D printed eye model with PETG film provides an excellent alternative for laser practice. The laser spots resemble those on the human retina [Fig. 7].

#### **C. Hands-on transfer of surgical skills in OR**

After learning the basic principles of VR surgery and training on goat eyes, and simulators to perfect hand-eye coordination and psychomotor skills, the next step is a hands-on transfer of surgical skills to fellow trainees under the direct supervision of a VR consultant in the OR.

Stepwise surgical training was imparted:

Step I: Applying sclera buckle; making and closing sclerotomy ports.

Step II: Performing core vitrectomy.

Step III: Learning technique of staining, inducing posterior vitreous detachment

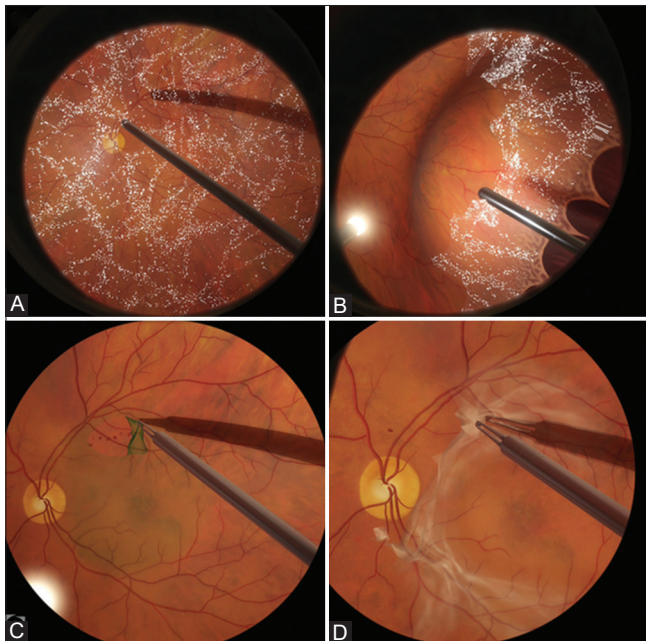
Step IV: Performing fluid air exchange (FAE), silicon oil tamponade.

Step V: Learning technique of phacofragmentation, intraocular foreign body removal.

Step VI: Learning complex tasks like ILM/ERM peeling, managing complex retinal detachments.

This stepwise approach is a systematic way of imparting surgical training to fellow trainees.

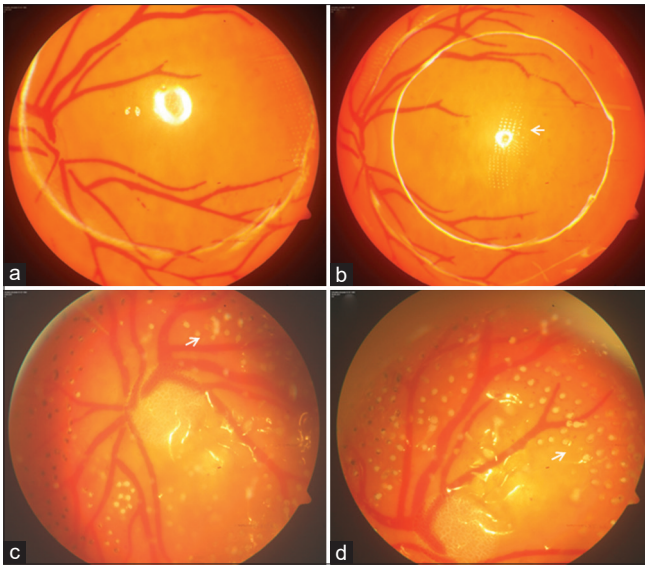
The trainees are mentored by the senior VR surgeons. They can move to the next step only after it has been approved the mentor. Mastering one surgical step at a time in direct guidance of their faculty/surgical mentors gives them confidence and is an objective method of learning correct surgical techniques. The trainees moved to learn complex surgical skills after acquiring basic ones in an orderly manner. As surgical experience grows,



**Figure 5:** Snapshots of various tasks performed by fellow trainees on Eyesi Surgical Simulator. Panel A shows induction of posterior vitreous detachment after staining of posterior hyaloid using suction of cutter. Peripheral vitreous dissection with sclera depression is shown in Panel B. Internal limiting membrane and epiretinal membrane peeling are shown in Panels C and D, respectively



**Figure 6:** The 3D printed model eye is fixed in place using a metallic handle upon slit-lamp laser delivery system (a and b) A trainee practicing laser photocoagulation (c)



**Figure 7:** Inside view of the 3D printed model eye. Fundus image captured using Visupac, Carl Zeiss fundus camera shows polyethylene terephthalate glycol (PETG) sheet prior to laser photocoagulation (a) the model can be used to practice macular photocoagulation (b) or pan-retinal photocoagulation (c and d)

the fellow becomes independent, and the faculty/surgical mentor performs a supervisory role.

Any surgical program comprises four levels of fellow training:

- I. Consultant performing surgery, trainee assisting: Surgical training starts with trainees helping and observing their surgical mentors.
- II. Trainee doing, consultant scrubbed, and assisting: Trainees start performing steps/tasks under direct supervision and guidance of their mentors.
- III. The trainee doing, consultant in the operation theater (OT) lounge monitoring on TV: Once the trainee masters basic surgical skills, they start performing surgeries independently while the consultant monitors on TV in OT lounge.
- IV. Trainee doing, consultant in his OPD/office: As trainees become trained and gain confidence, they can perform surgeries independently while faculty/surgical mentors are just a call away if the need arises.

#### Feedback from fellow trainees

Throughout the training program, the trainees maintained surgical logbooks and evaluation sheets of surgical tasks performed by them duly signed by the attending consultant, in which they recorded their experience and learning from each case.

The trainees trained on the simulator and in the wet lab, and felt confident while doing actual surgeries in the operating room later. The stepwise approach to the surgical training helped to gain efficiency in complex tasks/procedures. Positive feedback from the trainees highlights that vitreoretinal surgical training programs need to evolve to address the demands of the current era.

## Discussion

Historically vitreoretinal surgical training, like other surgical specialties, was based on a Halstedian model of apprenticeship learning. Trainees completing a minimum

number of surgical procedures are assumed to be competent. However, due to inconsistent levels of knowledge and skills gained because of variations in clinical exposure and educational opportunities,<sup>[12]</sup> using the total number of procedures that a trainee has performed as a benchmark for talent is problematic. Quantity does not always equate to quality. Furthermore, there are growing ethical concerns over the use of patients for training purposes.<sup>[13]</sup> The current scenario, changing clinical scenario, and professional values highlighted the need to review this approach even before the pandemic.<sup>[14]</sup> Of late, there has been a trend of migration from an apprenticeship model to a competency-based model in postgraduate medical education. Greater importance is now being placed on formally incorporating surgical simulation in the training of surgeons. This transition in the methodology of surgical training has only been fast-forwarded in the current pandemic because of the drying up of surgical opportunities for the trainees.

Kirby was the first to propose a surgical wet lab model for ophthalmic surgical training in 1966.<sup>[15]</sup> Since then, the residency training programs throughout the world have incorporated wet lab training to help trainees acquire surgical competence and master essential skills required for intraocular procedures.<sup>[16,17]</sup> A systematic and structured wet lab training curriculum has been shown to reduce the rate of complications and improve the cataract surgical outcome in trainee surgeons.<sup>[18,19]</sup> Similarly, a wet lab setting has been used to demonstrate and teach the technique of sclera buckling<sup>[20]</sup> and vitrectomy.<sup>[21–23]</sup>

In our program, wet lab training on goat eyes using an ophthalmic microscope and vitrectomy machine helped trainees develop hand–eye coordination and the psychomotor skills required for vitreoretinal surgery. The trainees felt confident and better equipped when they later started performing surgical steps on patients in the OR.

Vitreoretinal surgery involves learning special skills and performing tasks, all of which are difficult to master in a wet lab alone using goat eyes. Simulator training helps filling up this lacuna by providing a near-actual surgical environment for training. Hunter *et al.*<sup>[24]</sup> first reported computer-simulated ocular surgery in 1993. Hikichi *et al.*<sup>[25]</sup> first described the use of a simulator for vitreoretinal surgical training. Simulator training allows for performing complex surgical tasks without compromising patient safety and medical ethics involving patients.<sup>[26,27]</sup> Also, the simulator acts as a thoroughly validated surgical training tool with minimal risk of bias.<sup>[28,29]</sup> EyeSi®Surgical Simulator (VRMagic, Mannheim, Germany) has been shown to play a helpful role in acquiring a variety of surgical skills.<sup>[30–33]</sup> Feedback from fellow trainees from our center highlighted the beneficial role of simulator training in developing VR skills. The trainees felt they were more oriented and prepared for surgical tasks post simulator training.

Currently, there is a lack of literature on the effectiveness of skill transfer from virtual reality environment to the operation room for vitreoretinal surgeries. Whether the preparation at the simulator affects the surgical performance or improves actual pars plana vitrectomy (PPV) performance in retinal reattachment surgery is still unknown. Deuchlers *et al.*<sup>[34]</sup> studied the efficacy of the virtual reality training simulator Eyesi in preparing surgeons for performing pars plana vitrectomies. They found a statistically significant relationship



between the performance at the simulator and in the operating room.

In our program, we observed a faster adoption of skills and more talent in performing surgical tasks post simulator training by the trainees. However, these were subjective measures, and we could not use an objective standard to ascertain the efficacy of simulator training. Further studies are needed to support the transfer of skills from the simulator to the operating room. We are designing such studies to see whether performance on a simulator can be reciprocated in the actual situation.

Eyeball models for surgical training have been previously described. An eyeball model created using a ping pong ball for practice for slit-lamp laser photocoagulation described by Ganne *et al.*<sup>[35]</sup> developed a low-cost model using pre-printed fundus images on paper to impart training in retinal lasers and fundus photography. Similarly, Pugalendhi *et al.*<sup>[36]</sup> recently developed a plastic model eye for retina laser using additive manufacturing. Chhabra *et al.*<sup>[37]</sup> developed a 3D printed model eye, RetiSurge, for enabling vitreoretinal surgical training. Damodaran *et al.*<sup>[38]</sup> used citrus lemon markings of the surface anatomy of eyeballs made using a marker pen to teach suturing skills for sclera buckle. Our training program's 3D printed eye model enabled the trainees to practice LP and orient themselves to image inversion and laser beam focusing.

Wet lab and simulator training act as a warm-up or preparatory measure, and the ultimate aim is to train the fellow trainees for vitreoretinal surgeries in patients. Hands-on transfer of surgical skills to trainees under the direct supervision of a VR consultant in the OR remains the gold standard in VR training. However, stepwise training of surgical steps is a useful approach to master individual skills before performing independent procedures. This also gives confidence and reduces stress from novice surgeons. Our trainees felt this approach to be beneficial in improving their surgical skills.

## Conclusion

To conclude, reforms in VR surgical training programs were long due, with their need only being more felt in this pandemic. The need of the hour is a multi-pronged approach to impart surgical training to fellow trainees. The COVID-19 global pandemic era, on the one hand, has disrupted training programs worldwide while at the same time provided us with the opportunity to evolve and formulate residency programs for the future that offers practical training and are independent of the patient flow. It is high time that we invest in recharting our surgical training programs to produce competent vitreoretinal surgeons of the future.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

## References

- Fero KE, Weinberger JM, Lerman S, Bergman J. Perceived Impact of urologic surgery training program modifications due to COVID-19 in the United States. *Urology* 2020;143:62-7.
- Zingaretti N, Contessi Negrini F, Tel A, Tresoldi MM, Bresadola V, Parodi PC The impact of COVID-19 on plastic surgery residency training. *Aesthetic Plast Surg* 2020;26:1381-5.
- COVIDSurg Collaborative. Elective surgery cancellations due to the COVID-19 pandemic: Global predictive modelling to inform surgical recovery plans. *Br J Surg* 2020;107:1440-9.
- Porpiglia F, Checcucci E, Amparore D, Verri P, Campi R, Claps F, *et al.* Slowdown of urology residents' learning curve during the COVID-19 emergency. *BJU Int* 2020;125:E15-7.
- Hu VH, Watts E, Burton M, Kyari F, Mathenge C, Heidary F, *et al.* Protecting yourself and your patients from COVID-19 in eye care. *Community Eye Health* 2020;33:S1-6.
- Nguyen AX, Gervasio KA, Wu AY. Differences in SARS-CoV-2 recommendations from major ophthalmology societies worldwide. *BMJ Open Ophthalmol* 2020;5:e000525.
- Mazinani BA, Rajendram A, Walter P, Roessler GF. Does surgical experience have an effect on the success of retinal detachment surgery? *Retina* 2012;32:32-7.
- Potter TJ, Hollowell GD, Bowen IM. Ultrasonographic anatomy of the bovine eye. *Vet Radiol Ultrasound* 2008;49:172-5.
- Ribeiro AP, Silva ML, Rosa JP, Souza SF, Teixeira IA, Laus JL. Ultrasonographic and echobiometric findings in the eyes of Saanen goats of different ages. *Vet Ophthalmol* 2009;12:313-7.
- Grodin MH, Johnson TM, Acree JL, Glaser BM. Ophthalmic surgical training: A curriculum to enhance surgical simulation. *Retina (Philadelphia, Pa)* 2008;28:1509-14.
- Zendejas B, Brydges R, Hamstra SJ, Cook DA. State of the evidence on simulation-based training for laparoscopic surgery: A systematic review. *Ann Surg* 2013;257:586-93.
- Zhou AW, Noble J, Lam WC. Canadian ophthalmology residency training: An evaluation of resident satisfaction and comparison with international standards. *Can J Ophthalmol* 2009;44:540-7.
- Gallagher AG, Traynor O. Simulation in surgery: Opportunity or threat? *Ir J Med Sci* 2008;177:283-7.
- Reznick RK, MacRae H. Teaching surgical skills changes in the wind. *N Engl J Med* 2006;355:2664-9.
- Kirby TJ. A course in surgical technique for residents in ophthalmology. *Trans Am Ophthalmol Soc* 1983;81:333-57.
- Raj D L, Anandan H. Contemporary appraisal on wet-laboratory training for ophthalmology residents. *TNOA J Ophthalmic Sci Res* 2019;57:84-6.
- Ramani S, Pradeep TG, Sundaresh DD. Effect of wet-laboratory training on resident performed manual small-incision cataract surgery. *Indian J Ophthalmol* 2018;66:793-7.
- Rogers GM, Oetting TA, Lee AG, Grignon C, Greenlee E, Johnson AT, *et al.* Impact of a structured surgical curriculum on ophthalmic resident cataract surgery complication rates. *J Cataract Refract Surg* 2009;35:1956-60.
- Farooqui JH, Jaramillo A, Sharma M, Gomaa A. Use of modified international council of ophthalmology-ophthalmology surgical competency assessment rubric (ICO-OSCAR) for phacoemulsification-wet lab training in residency program. *Indian J Ophthalmol* 2017;65:898-9.
- Pujari A, Kumar S, Markan A, Chawla R, Damodaran S, Kumar A. Buckling surgery on a goat's eye: A simple technique to enhance residents' surgical skill. *Indian J Ophthalmol* 2019;67:1327-8.
- Borirak-chanyavat S, Lindquist TD, Kaplan HJ. A cadaveric eye model for practicing anterior and posterior segment surgeries. *Ophthalmology* 1995;102:1932-5.
- Shah VA, Reddy AK, Bonham AJ, Sabates NR, Lee AG. Resident surgical practice patterns for vitreoretinal surgery in ophthalmic training programs in the United States. *Ophthalmology* 2009;116:783-9.
- Lauer A, Chan-Kai, Lauer A. Basic training module for vitreoretinal surgery and the Casey Eye Institute vitrectomy indices tool for skills assessment. *Clin Ophthalmol* 2011;5:1249-56.

24. Hunter IW, Doukoglou TD, Lafontaine SR, Charette PG, Jones LA, Sagar MA, *et al.* A teleoperated microsurgical robot and associated virtual environment for eye surgery. *Presence* 1993;2:265–80.
25. Hikichi T, Yoshida A, Igarashi S, Mukai N, Harada M, Muroi K, *et al.* Vitreous surgery simulator. *Arch Ophthalmol* 2000;118:1679–81.
26. Padilha JM, Machado PP, Ribeiro A, Ramos J, Costa P. Clinical virtual simulation in nursing education: Randomized controlled trial. *J Med Internet Res* 2019;21:e11529.
27. Kolozsvari NO, Feldman LS, Vassiliou MC, Demyttenaere S, Hoover ML. Sim one, do one, teach one: Considerations in designing training curricula for surgical simulation. *J Surg Educ* 2011;68:421–7.
28. Ahmed TM, Rehman Siddiqui MA. The role of simulators in improving vitreoretinal surgery training - A systematic review. *J Pak Med Assoc* 2021;71(Suppl 1):S106-11.
29. Vergmann AS, Vestergaard AH, Grauslund J. Virtual vitreoretinal surgery: Validation of a training programme. *Acta Ophthalmol* 2017;95:60–5.
30. Park L, Song JJ, Dodick JM, Helveston EM. The EYESI 2.2 ophthalmosurgical simulator: Is it a good teaching tool? *Investig Ophthalmol Vis Sci* 2006;47:4421.
31. Rossi JV, Verma D, Fujii GY, Lakhanpal RR, Wu SL, Humayun MS, *et al.* Virtual vitreoretinal surgical simulator as a training tool. *Retina* 2004;24:231–6.
32. Rasmussen RC, Grauslund J, Vergmann AS. Simulation training in vitreoretinal surgery: A systematic review. *BMC Ophthalmol* 2019;19:90.
33. Lee R, Raison N, Lau WY, Aydin A, Dasgupta P, Ahmed K, *et al.* A systematic review of simulation-based training tools for technical and non-technical skills in ophthalmology. *Eye (Lond)* 2020;34:1737-59.
34. Deuchler S, Wagner C, Singh P, Müller M, Al-Dwairi R, Benjilali R, *et al.* Clinical efficacy of simulated vitreoretinal surgery to prepare surgeons for the upcoming intervention in the operating room. *PLoS One* 2016;11:e0150690.
35. Ganne P, Krishnappa NC, Baskaran P, Sulaiman SM, Venkatesh R. Retinal laser and photography practice eye model: A cost-effective innovation to improve training through simulation. *Retina* 2018;38:207-10.
36. Pugalendhi A, Ranganathan R, Venkatapathy N, Narendran K, Shah PK. Design and development of model eye for retina laser by using additive manufacturing. *Proc Inst Mech Eng H* 2021;235:89-98.
37. Chhabra K, Khanna V, Vedachalam R, Sindal M. RetiSurge - Enabling «Dry Lab» vitreoretinal surgical training during COVID-19 pandemic. *Indian J Ophthalmol* 2021;69:982-4.
38. Damodaran S, Babu N, Sen S, Arthur D. Learning to buckle the sclera - The organic bench model for learning suturing skills. *Indian J Ophthalmol* 2021;69:1013-4.