Research Article

Technology Driven Mitigation of COVID-19 Infection Risk in Retinal Surgery, by means of 3D Visualization Systems

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Received: 04 September 2020; **Accepted:** 16 September 2020; **Published:** 22 September 2020

Citation: George Pappas, Nectarios Vidakis, Markos Petousis. Technology Driven Mitigation of COVID-19 Infection Risk in Retinal Surgery, by means of 3D Visualization Systems. Journal of Ophthalmology and Research 3 (2020): 65-70.

Abstract

In cases in which the proximity of the medical personnel and the patient is necessary, such as in ophthalmology, both the medical personnel and the patient have high infection risk from each other's respiratory system secretions, which can float in a range usually larger than the required proximity of such medical operations. In this work, the authors examine and evaluate the infection risk change between the ordinary retinal operation practice with microscope and the one with utilizing a 3D visualization system, by keeping the other surgery conditions untouched. It was found that the 3D visualization provides a significant reduction of the COVID-19 infection risk for the surgeon, his paramedics' assistant, and the patient. Many reasons trigger ophthalmologists to use this new way of operating; The ergonomics for the surgeon, the excellent image quality, the better depth of view, the ability to reproduce large differences in bright and dark conditions to retain details and depends on the ability of the human pupil to fluctuate in size, the ability to change lighting conditions, the teaching potential and the ease to adapt.

Keywords: Retina; Ophthalmologic surgery; 3D visualization; COVID-19

Introduction

During the second outbreak of the COVID-19 pandemics, the health-care systems and the medical/surgical practices require another, more sophisticated and poly-parametric perspective, in order to diminish the infection risk [1]. Each single medical activity, operation or protocol has to be reevaluated and probably redesigned, in the view of the pandemic's incidence. Hereto, the mostly qualitative instructions, protocols and standards for the self-protection and the safety of the health-care personnel and patients, have to be also quantitatively assessed, whenever applicable [2]. To this view, the massive effort of the research and the medical community to document and moderate the infection risk, can be exploited more effectively by the health care system.

Globally, the first MD victim that died of infection with the SARS-CoV-2, i.e. Dr. Li Wenliang from Wuhan, China [3], was the ophthalmologist that sounded the alert of the novel respiratory syndrome and warned doctors to use self-safety and protection features. Therefore, the ophthalmology research and medical communities are highly sensitized and seek for practices that increase the protection of the patients and the medical personnel [1]. Rather to the social distancing in healthcare, which depicts infection risk mitigation measures, such as telemedicine, virtual check-in and e-visits [4], in physical medical actions in ophthalmology there is an increased physical proximity between the doctor and the patient. Therefore, ophthalmology is considered as a specialty with high infection risk, especially by asymptomatic patients. To this perspective, a variety of personal protective features for eye doctors has been adopted, such as face masks, gloves, goggles, cap, gown, slit-lamp biomicroscope shields and temperature screens [1]. Various countries have implemented various combinations of the features above, for their eye hospitals and clinics [1].

Further to the nomination of the personal protection features that were found to mitigate the COVID-19 infection risk, a volume of statistical analyses and meta-analyses quantified the Relative [RR] or the Absolute [AR] infection Risk after their adoption [3]. In a recent research work [3], one more important parameter, i.e the RR and the AR change with increasing the distance. This work is a metanalysis of many former published researches for the infection risk for SARS, MERS and COVID-19. It is reasonable to assume that the infection risk is reduced by increasing the physical distance of persons, taking into account that the virus is mainly transmitted through airborne droplets from the upper respiratory system (nose, mouth), which owing to gravity fall down to the floor [5]. The importance of these findings for medical specialties of increased doctor/patient proximity and therefore high infection risk (ophthalmology, otorhinolaryngology, anesthesiology etc), is based on the possibility to evaluate any alteration of the medical method in quantitative terms.

In this work, the authors examine and evaluate the infection risk change between the ordinary retinal operation practice with microscope and the one with utilizing a 3D visualization system, by keeping the other surgery conditions untouched. For the comparative study of both methods the ALCON LX3 ophthalmic surgery microscope was used, without or with the NGENUITY 3D digital visualization system. Both cases are capable to be used in any kind of ophthalmic surgery, such as cataracts, squints, buckings, trabeculectomies, valves, vitrectomies etc. It will be illustrated below that the utilization of the 3D visualization provides a significant reduction of the COVID-19 infection risk for the surgeon, his paramedics' assistant, and the patient.

In cases in which the proximity of the medical personnel and the patient is necessary, such as in ophthalmology, both the medical personnel and the patient have high infection risk from each other's respiratory system secretions, which can float in a range usually larger than the required proximity of such medical operations [1]. So, there is a zone between the medical personnel and the patient respiratory systems, in which floating droplets increase the infection risk. Protective measures reduce this risk, and this has been quantified in literature [6], making the evaluation of the infection risk of each medical operation possible, according to its conditions and measures.

Quantitative Risk Evaluation of Ophthalmic Surgery Strategies

Ordinary Retinal Operation Practice with Microscope

Figure 1 shows a typical ordinary retinal operation practice with microscope. As it is shown, the doctor has to place his eyes on the microscope, thus approaching the patient very closely. The distance between the doctor's and the patient's mouth is approximately 48cm (depending mainly on the posture and the height of the doctor), while the droplets zone is approximately 25cm. Also, in this case, usually the doctor is not wearing any googles, in order to be able to see through the microscope. Additionally, the rest of the second surgeon has to approach close to the doctor, in order to be able to assist him through the procedures.

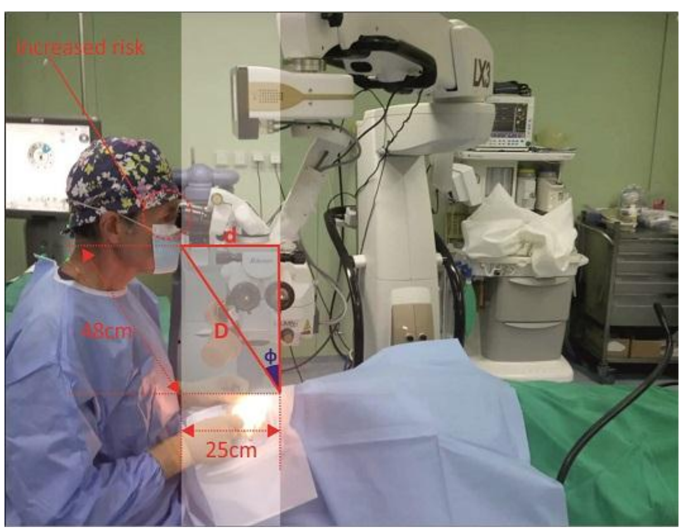


Figure 1: Ordinary Retinal Operation Practice with Microscope. The critical distances and the floating droplets zone are marked in the picture.

3D Visualization Systems in Retinal Surgery

Figure 2 shows a retinal operation practice with 3D visualization systems. As it is shown, in this case, the distance between the doctor's and the patient's mouth is approximately 82cm (depending again on the posture and the height of the doctor), while the droplets zone is approximately 61cm. Also, in this case, the doctor is wearing googles. Additionally, the assistant does not need to approach close to the patient, in order to be able to assist the doctor through the procedures.

A Comparative Qualitative and Quantitative Assessment

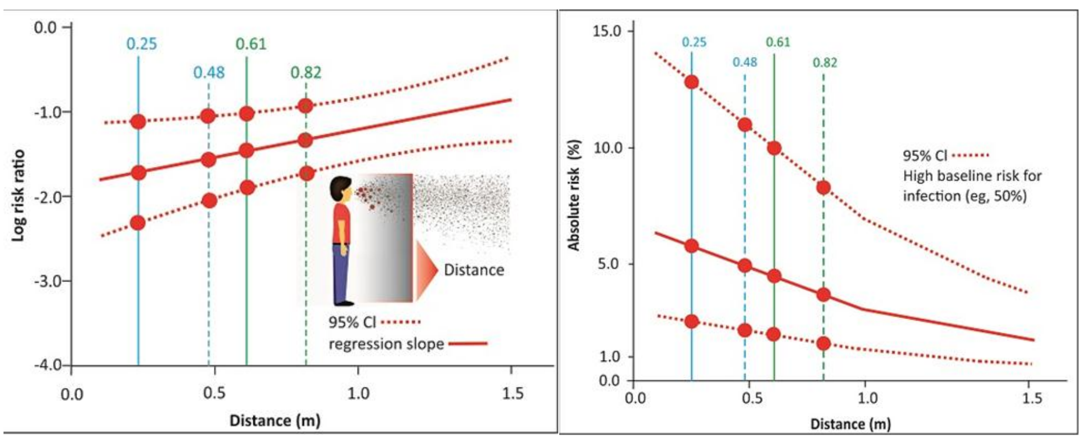
When comparing the two methods, as it is shown in the figures 1 and 2, the 3D visualization system offers a better sitting position over the patient, which lowers the risk of infection. Operating with the NGENUITY 3D system is increasing the distance between surgeons and patient's mouth by about 70% (48cm to 82cm). According to risk graphs from literature (figure 3) [3], this increase in the distance is reducing the absolute infection risk from approximately 5% to 4%, which is a 20% reduction, while the risk ratio [RR] is increased from 3% to 4.5%, a 50% increase. Also, the angle from the patient's vertical axis starting from his mouth is increased from approximately 31.33 degrees to 48.07 degrees, which is a 65% increase.

Figure 2: 3D Visualization Systems in Retinal Surgery. The critical distances and the floating droplets zone are marked in the picture.

The horizontal distance between the doctor's and the patient's mouth (floating droplets zone) is increased by 244% (25cm to 61cm). This reduces the risk droplets from patient's mouth to contaminate the surgeon. The absolute infection risk in this case is reduced from approximately 7.2% to 3.9%, which is a 46% reduction, while the risk ratio [RR] is increased from 1.9% to 4.0%, which is an about 100% increase.

Using the 3D goggles provides an additional protection for contamination trough the conjunctiva route. Eye protection was associated with lower risk of infection (AR, 5.5% with eye protection vs. 16.0% with no eye protection, a 64% reduction in the infection risk). The protective measures taken by the ophthalmologist and a comparison on the infection risk for both cases studied are presented in table 1.

The reasons which trigger ophthalmologists to use this new way of operating and abandon the traditional way of surgery, with a microscope are many. The ergonomics for the surgeon [7], the excellent image quality, the better depth of view, the ability to reproduce large differences in bright and dark conditions to retain details and depends on the ability of the human pupil to fluctuate in size [8], the ability to change lighting conditions, the teaching potential and the ease to adapt. Additionally, the high magnification that can be used during surgery provides less burdens due to steaming, which, with the microscope, can be a problematic issue. Overall, the NGENUITY 3D system provides a better tool and a safer tool for ophthalmic surgeons in the COVID - 19 era.



(a) (b)

Figure 3: Graphs for (a) the Relative [RR] and (b) the Absolute [AR] infection Risk vs distance. The critical distances of this study are marked in the graphs (figure illustrated by Mrs. Fotini Petraki).

Method	Face mask	Gloves	Cap	Gown	Other measures	Goggles	Increased distance
Ordinary Retinal Operation Practice with Microscope	yes	yes	yes	yes	n/a	no [AR]16%	no [AR]7.2%
3D Visualization Systems in Retinal Surgery	yes	yes	yes	yes	n/a	yes [AR]5.5%	yes [AR]3.9%
Comparative [AR] Mitigation	**0.0%**	**0.0%**	**0.0 %**	**0.0%**	**0.0%**	**64.0%**	**46.0%**

Table 1: Comparison of the protection measures taken in ordinary retinal operation and retinal operation with 3D visualization systems (yes: existing, no: not existing, n/a: not applicable)

Financial Disclosure(s): This research received no external funding.

Acknowledgments: The authors would like to thank Mrs. Fotini Petraki for the preparation of the graphics and of the figures.

Conflict of interest: The authors declare no conflict of interest.

- The content is solely the responsibility of the authors and does not necessarily represent the official views of the General Hospital Venizelio or the Hellenic Mediterranean University.
- No author has a proprietary interest on this work.
- All authors contributed equally as first authors.

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