

How Covid-19 Affected Pivots of Ophthalmology- 'The Optics and the Eyes'

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Abstract

Background: The pandemic has forced the healthcare system to adopt newer approach towards patient care. With the changing scenario of healthcare delivery, Ophthalmologists had to bring about several changes in the way the patients are seen and operated upon. Contact procedures were entirely restricted to emergencies while modifications were introduced to minimize the exposure of the surgeon. However, these modifications were introduced just keeping in mind the spread of infection. The probability that these modifications could affect the optics in ophthalmology is high and cannot be ruled out.

Aim: To highlight the effects of modifications introduced in ophthalmic equipment during the pandemic over the visibility for the surgeon and discuss its impact on patient-care in ophthalmology

Design and Methods: Thorough search of literature on PubMed using keywords visibility and PPE (Personal Protection Equipment), fogging and PPE, face mask and fogging, aberrations and PPE, surgeries and PPE was done. We found 35 articles which highlighted the effects on visibility with PPE and effects on eyes with prolonged wearing of masks.

Results: Several factors have contributed to reduction in visibility for the surgeon. These factors have in turn affected the overall quality of examination and surgical outcome in Ophthalmology.

Conclusions: The use of PPE during the pandemic could have been a contributory factor for missing relevant findings during examination of patients. For Ophthalmologists in particular the visibility and optics play a crucial role in management of the patient and has been invariably affected by introduction of modifications at the instrument and surgeon level.

Introduction

Interactions of light with various media depend upon diverse factors. Optics, as a precept, is the branch of physics that deals with the properties of light. Optical science applies to many disciplines, like astrophysics, numerous engineering fields, and medicine (especially ophthalmology and optometry). In ophthalmology, it is referred to as 'physiological optics' and is focused on the sight and functioning of equipment.

The principles of optics play a significant role in the operating of ophthalmic equipment. Further, the precision and accuracy with which these instruments function depends upon other factors like examination room lighting, quality of lenses, patient comfort and cooperation, visual acuity of both patient and examiner, and several other factors. The requirement for accuracy rises as we advance from OPD to laser room to Operation Theater (OT) and is a must in ophthalmology as maximum permissible error while operating on an eyeball is within microns. Ophthalmology examinations also demand impeccable visual clarity, as failure to timely diagnose can prove catastrophically debilitating for the patient.

Until the spread of the COVID-19 pandemic, the primary interests of researchers, lens makers, and equipment manufacturers were focused on enhancing the optical standards of examination lenses and ophthalmic instruments. Today, however, the pandemic and the accompanying implementation of the compulsory use of personal protective equipment (PPE) have brought an unprecedented factor that has notably affected the overall optical quality of ophthalmological examination. We know that these instruments function on highly precise optics and need timely calibration and maintenance to yield

the best performance. Thus, the introduction of modifications in the specified function of equipment may significantly reduce the image quality. Also, there are no recommended guidelines for the material being used to produce PPE. The manufacturing of PPE is being done on a mass scale with no description of its acceptability for use with ophthalmic instruments.

Hence, we propose that the recent adaptations made in ophthalmic devices to fight the pandemic might have considerably influenced the optical quality of ophthalmic procedures. We believe that the use of PPE has brought changes in the dynamics of optics in ophthalmology by affecting the visibility during examination and surgery.

In this article, the authors outline the effects of modifications introduced in ophthalmic equipment at the user and instrument level during the pandemic and discuss the quality of examination and the

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long-term implications they might have.

Face Shield, Goggles and Masks Related Aberrations

Indirect Ophthalmoscope (IDO)

Through our knowledge of optics, we know that the bending of light rays in a medium depends on the optical density of the medium and the angle at which the beam of light interacts with the medium [1]. Both these properties of light are quintessential for an error-free evaluation in ophthalmology and are likely to be hindered by the use of additional media between the treating surgeon and the microscope, like face shields and goggles. Chromatic differences in magnification because of variations in refractive indices in the media, although insignificant, are liable to produce altered judgment by a surgeon during surgery and laser especially in patients where very little can be visualized due to haziness of media. Face shields and protective goggles made of thick polycarbonate material are also likely to cause chromatic aberrations, leading to a changed perception of findings in an eye. Surgeons may also perceive ghost images with the use of thick goggles which might give a false perception of retinal pathology on indirect ophthalmoscopy.

Some ophthalmology centres have modified indirect ophthalmoscopes (IDO) and direct ophthalmoscopes (DO) with face shields mounted on the headpiece/ instrument, for the safe examination of patients during the pandemic [2]. We believe that with the addition of shields made of material that do not meet the optical standards applicable for ophthalmic procedures, the clarity and the quality of the examination will be significantly compromised. Chromatic aberrations and altered depth perception by a surgeon can also be expected with these shields when they are loosely attached over the headpiece of IDO. Further, fogging of the hand-held lens due to expired air from the patient's ill-fitted mask can prove arduous while carrying out the examination.

90 D Slit-Lamp Examination

Slit-lamp bio microscopy, when coupled with non-contact lenses, to perform the fundus examination can generate significant unwanted reflections [3]. Matthew et al have discussed different obscuration designs for slit-lamp bio microscopy to make the reflections coming from pre-corneal tear film and fundus lens conjugate with these reflecting surfaces [3]. In a routine, however, these reflections cannot be entirely eliminated while doing slit-lamp bio microscopy. The quality of examination with high power positive lenses on a slit lamp can further become complex with the use of face masks by the examiner and the patient. This can cause significant fogging of the indirect lens towards the patient and slit lamp optics towards the examiner, making the process more time-consuming and challenging to perform. Also, several factors like fogging, difficult maneuvering of the instrument with an added shield in between can impede the examination process for both the doctor and the patient which may lead to missed findings. Further, the patient's inability to cooperate because of apprehension of significantly close contact during the examination added barriers on slit lamps, and face masks can make the examination process difficult for the ophthalmologists. Adding to that, the time taken for examination invariably increases because of the addition of a protective shield to slit lamp, fogging and the requirement of repeated readjustments to cater for reflections and fogging.

Contact Procedures

With the spread of the pandemic and reinforcement of laws

to prevent the spread of COVID-19 several key steps were taken by the health community. Of those, limiting patient visits to clinics and introducing teleconsultation have helped sustain healthcare while the pandemic was at its full pace [4-6]. In ophthalmology, several key steps in the examination were affected because of new guidelines to prevent the spread of infection.

Direct ophthalmoscopy (DO) is one of the fastest ways to examine and triage patients in ophthalmology and also provides for a detailed and magnified view of the patient's fundus [7]. However, during the pandemic, direct ophthalmoscopy ceased to exist during the pandemic as it is a closed contact examination. The inability to perform DO in a routine clinical set-up might have delayed the timely treatment of patients suffering from new-onset diabetic and hypertensive retinopathy during the pandemic. With global encouragement for teleconsultation and minimizing clinic visits, there are chances of having missed some of these patients who could be managed conservatively. These might now turn up to us with a more advanced stage of the disease.

In their commentary, Kendrick et al have proposed their concern regarding the inability of ophthalmologists to carry out close contact procedures; direct ophthalmoscopy in particular [7]. Direct ophthalmoscopy has also been one of the preliminary diagnostic procedures in ophthalmology. In an era of the pandemic, it has become difficult to teach this basic investigative procedure to doctors in making [7]. It hinders the systematic approach to examining and treating the patients and might affect the way the patients are examined in future as present generations are relying more on indirect procedures and fundus imaging, almost entirely omitting the close contact procedures.

Other contact procedures like gonioscopy and Goldmann Applanation Tonometry (GAT) were carried out with precautions [8]. These procedures provide crucial information while treating a patient with glaucoma and are vital for timely action-taking. Further, most of these patients were also encouraged to follow up via teleconsultation to cater for the burden of the pandemic on the health sector [5]. Louis et al suggested that in the absence of adequate follow up we can expect several patients to turn up in a more advanced stage of disease and develop sight-threatening complications.

Operating With Personal Protective Equipment (PPE)

Fogging of spectacles used by surgeons is another prevalent concern among the medical community and is implicated in the significant reduction of visual acuity. As per the study conducted by Arthur et al., respirator masks used during fire hazards and calamities can limit the visual acuity of subjects to a significant degree [9]. They reported a 1% reduction in saccadic test performance and an 11% reduction in hand-eye coordination among their study participants. The respirator masks used in their study cover the eyes and face of the observer. The PPE used by doctors during the pandemic involved the use of protective goggles and N-95 masks. These act as similar barriers and are significantly comparable. The results of their study can explain the perceived reduction in performance by surgeons with the use of PPE as quoted in several studies. This is however based only upon subjective analysis by surgeons and there is a need for researchers to analyze the same in detail. The performance of the surgeon while operating is crucial for the surgical outcome and can considerably increase the burden of post-op complications if hampered. Microsurgeries in ophthalmology can significantly be affected by any physiological distress faced by the surgeon during the surgery. Cornea donor tissue preparation and transplantation, retinal repair, retinal detachment surgeries etc. can only be performed by a skilled surgeon. If however,

the judgment capacity of the surgeon is halted because of the use of PPE, as suggested by reports, the outcomes of the surgery may be affected [10]. Further, effects on surgical performance are likely to augment the risk of complications associated with surgery. Poor decision making while performing surgeries has been reported in several studies and is a risk factor that needs to be addressed [10]. Increased eye-microscope distance due to protective goggles used while performing procedures can also reduce the field of view for a surgeon operating under a microscope. A reduction in the field of view coupled with other factors like fogging can halt the capacity of a surgeon to perform at his/her full potential [11]. Clamp and Broomfield have discussed in detail the effects of different protective equipment on the surgical field of view while operating under a microscope [11]. Protective equipment like face visors were found to be incompatible with the microscope, giving less than 10 per cent of the microscopic view. Other protective equipment like safety glasses when worn with a surgeon's spectacle prescription gave variable results when tested under the operating microscope and in some cases also increased the eye-microscope distance [11]. Alteration in the depth perception is also likely along with the changed perception of colour. Reinaldo et al have demonstrated significant restrictions in visual acuity, colour perception and contrast sensitivity while performing endoscopy with PPE [12]. Additionally, their study has reported further deterioration of these parameters with the course of the procedure. The results of their study highlight the fact that surgery performed with PPE for a longer duration is likely to be worse affected than a small procedure [12].

Mask Related Aberrations in Visual Field Analysis (VEA)

Several studies have shown that face masks can significantly affect the performance of normal individuals for visual field testing. El-Nimri et al. have shown in their study that an ill-fitted face mask can produce unreliable visual field testing with some artefacts equitable to the visual field loss from glaucoma [13]. They have also shown that even in a mask where taping over nose bridge was done there was worsening of visual field results, suggesting that any amount of fogging can disguise as visual field defects. In such a scenario, the follow-up and analysis of the progression of glaucoma become unreliable as the test results are liable to be affected by external sources. On the other hand, studies have shown that taping of a face mask can be beneficial for reducing the visual field loss contributed by the face masks and hence it is suggested that surgeons tape their mask over the bridge of the nose while performing surgeries [13]. Similar effects can be seen due to fogging of the trial lens while testing the patient's best-corrected visual acuity. Here again, the fogging of trial lenses due to leaking of exhaled air from a patient's ill-fitted mask can lead to misleading results.

Reuse of PPE

The reuse of protective eyewear is also a topic of concern. Considering the huge demand and supply gap there were suggestions to reuse the protective eye goggles and shields. Although, these equipment made of polycarbonate are not resistant to scratches. Arthur et al. demonstrated in their study that using protective eyewear with scratches is liable to reduce the visual acuity of the wearer from 20/20 to 20/30 [14].

Face Masks and Dry Eyes

Worldwide, the use of face masks for the prevention of COVID-19 has been associated with dry eyes [15]. The proposed aetiology is the exhaled air leaking through the bridge of the nose of a continuously worn mask that comes directly in contact with the ocular surface and

can lead to faster evaporation of tear film. Pedro et al. have shown that the use of face masks can significantly reduce tear film stability in face mask wearers [16]. Aksoy et al have suggested that taping of the mask over the bridge of the nose can help prevent these symptoms significantly in prolonged face mask users [17]. In a case report, Tang et al. have described the potential role of prolonged use of face masks in recurrent corneal erosion syndrome which was complicated by microbial keratitis [18]. The unrealized implications for health workers and surgeons in such a scenario can be prolonged.

Eye Strain and Headache with Face Masks

With over a year of usage of face masks globally, it is now understood that prolonged wearing of face-mask can have certain physiological impacts. Several studies have discussed the elevation of blood carbon dioxide (CO₂) levels in healthcare workers after prolonged wearing of face masks [19-21]. However, no significant change in blood oxygen (O₂) concentration was found in the studies.

Headache is one of the most prominent complaints amongst those who wear masks for more than four hours together [22, 20]. Several factors have been associated with headaches in face mask wearers. Some of them can be tight mask straps, dehydration, altered eating patterns.

Increased Risk of Exposure-Induced Photo-Retinitis

It is a well-known fact that sunlight is damaging to the eyes. The artificial light is used for examination and during surgery can also be said to cause damage to the retina of patients. A healthy retina can repair itself and overcome the light-induced damage, it is the diseased retina that will lack the capacity to recover from light-induced photo retinitis but will be exposed to light for a longer duration for thorough examination and surgery [23]. With the COVID-19 protective measures and modifications, the time for the examination can be said to have significantly increased. This plays a counterproductive role as increased examination time means greater risk of exposure to infection and higher phototoxicity delivered to diseased eyes.

Conclusion

The broader aspect of how the pandemic has affected the scenario of healthcare delivery needs to be analyzed by researchers. Ophthalmologists have used contact procedures like gonioscopy, tonometry and close contact procedures like direct ophthalmoscopy for times unknown. These modalities serve crucial in the diagnosis and timely detection of complications in patients. Although, with the spread of the COVID-19 these procedures were reserved for emergencies only. The loss of regular follow-up of these patients is likely to increase the burden on healthcare as more patients are likely to develop complications. Further, in developing countries, where access to healthcare is still limited, this may add to the burden of blindness. Ophthalmology, as a branch, is still in its developing phase and growing at a fast pace. The pandemic has highlighted the areas where improvements are possible. As ophthalmologists, we must consider it our responsibility to be able to deliver continuous patient care and to think of solutions for future preparedness. As a race, humans have fought against grave calamities in the past and the purpose of time should be to realize the gaps in the process only to learn from it and evolve.

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