



How glaucoma care changed for the better after the pandemic

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Purpose of review

The current article reviews enhancements to the delivery of glaucoma care that developed in response to the coronavirus disease 19 (COVID-19) pandemic and are likely to persist beyond its resolution.

Recent findings

Literature from the review period (2020–2021) includes reports highlighting contributions of the ophthalmology community to global health during the pandemic. Glaucoma practices worldwide have instituted more robust infection control measures to mitigate severe acute respiratory syndrome coronavirus 2 transmission in the outpatient setting, and many of these modifications will endure in the post-COVID era. Operational adjustments have led to the provision of more efficient glaucoma care. A hybrid care model involving technician-based diagnostic testing and subsequent virtual consultation with a glaucoma specialist has evolved as a useful adjunct to traditional face-to-face encounters with patients.

Summary

Glaucoma specialists, patients, and staff have adapted to a 'new normal' of glaucoma care delivery during the COVID-19 pandemic. Although innovation has propelled several improvements to glaucoma care during this global health crisis, significant barriers to more widespread implementation of teleglaucoma still exist. Whether, and in what capacity, the pandemic has permanently altered glaucoma practice patterns remains to be seen.

Keywords

coronavirus, glaucoma, pandemic, telemedicine, teleophthalmology

INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has resulted in 198 227 874 infections and 4223 255 deaths worldwide and 34 997 105 infections and 613 223 deaths in the United States as of 1 August 2021 [1]. The coronavirus disease 19 (COVID-19) pandemic has caused unprecedented devastation, not only in the toll of lives lost and enduring morbidity among survivors, but also its impact on the economy and society at large. The magnitude of this global health crisis is likely not yet fully realized. Fortunately, public health measures, including universal masking, hand hygiene, social distancing, and, more recently, vaccinations against COVID-19, have significantly reduced the rates of infection, hospitalization, and death in the United States.

While sanguinity in the face of such widespread tragedy is nearly inconceivable, the pandemic has redefined the role of the ophthalmologist in medicine and transformed the delivery of ophthalmic, and specifically glaucoma, care. Herein, we

highlight the ophthalmology community's contributions to the global fight against COVID-19 and review those aspects of glaucoma care that may have changed for the better after the pandemic.

REDEFINING THE OPHTHALMOLOGIST'S ROLE

Among the first to recognize the novel coronavirus was Dr Li Wenliang, an ophthalmologist who observed a SARS-like illness in seven patients under quarantine at Wuhan Central Hospital. After warning former medical school classmates via a

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KEY POINTS

- Major modifications implemented by glaucoma practices worldwide, ranging from enhanced disinfection protocols to implementation of single-use diagnostic instruments, will continue to optimize safety for patients, physicians, and staff in the post-COVID era.
- Reorganization of patient flow in the outpatient setting has streamlined in-person visits for patients with glaucoma.
- Hybrid models of glaucoma care harness the advantages of teleglaucoma by combining technician-driven data acquisition and virtual consultation with a glaucoma specialist.

messaging application on 30 December 2019, Dr Li subsequently contracted SARS-CoV-2 from an asymptomatic patient whom he treated for glaucoma. Dr Li died from complications of COVID-19 on 7 February 2020, aged 33 [2[■],3[■]].

Shortly thereafter, healthcare systems throughout the world rapidly became overburdened by soaring SARS-CoV-2 infection rates and shortages in hospital capacity, personal protective equipment (PPE), and ventilators. Healthcare workers, among them trainees, retired healthcare professionals, and specialists, including ophthalmologists, were called upon to bolster the front lines. At the height of the pandemic, some ophthalmologists were redeployed to emergency departments, ICUs, and medical wards, whereas others continued to provide urgent and emergent eye care [4[■]–10[■]]. Collectively, our varied experiences as ophthalmologists, and in particular glaucoma specialists, during the pandemic have likely increased our resilience, deepened our empathy, and heightened our vigilance toward our most vulnerable patients, preparing us to provide better care to our patients with glaucoma in the post-COVID era.

IMPROVING GLAUCOMA CARE

The COVID-19 pandemic has exacerbated existing challenges to the delivery of glaucoma care. Extended lockdowns and suspension of routine outpatient visits limited access to care among a population in which nonadherence to treatment and follow-up was already prevalent [11[■]]. Patients, particularly those whose age and systemic comorbidities increased their risk for complications from COVID-19 [12[■]], were forced to weigh their fears of glaucomatous progression and blindness due to missed appointments against concerns of contracting SARS-CoV-2 during in-person visits. Survey-

based studies have confirmed such patient perceptions [11[■],13[■]–18[■]]. Glaucoma practices have sought to mitigate viral transmission in the outpatient setting while minimizing ocular morbidity resulting from delays in care. Various measures undertaken to optimize safety, streamline visits, and implement teleglaucoma will persist well beyond the pandemic's resolution.

Optimizing safety

SARS-CoV-2 transmission occurs primarily via inhalation of respiratory droplets and aerosolized viral particles [19[■]], and, to a much lesser extent, contact with recently contaminated surfaces [20]. Ophthalmologists are at heightened risk for contracting SARS-CoV-2 and other respiratory illnesses from patients given the physical proximity required during the slit-lamp examination [21[■]]. The pandemic has therefore compelled ophthalmology practices to augment existing infection control policies to reduce viral transmission [22,23].

An indoor setting with poor ventilation and prolonged exposure time (>15 min) increases the risk of SARS-CoV-2 transmission [19[■],24]. As such, some ophthalmology practices have implemented environmental modifications to improve ventilation and avoid air recirculation, for example, by installing portable high efficiency particulate air filters in waiting rooms [5[■],25[■]–27[■]]. Such measures will prove useful indefinitely in regions affected by seasonal respiratory illnesses.

Several experiments have demonstrated the efficacy of slit-lamp breath shields, which serve as physical barriers between patients and examiners [28[■]–32[■]]. Chuan *et al.* [28[■]] demonstrated that the combined use of a slit-lamp breath shield and face mask worn by a simulated patient blocked virtually all droplets and aerosols from a simulated sneeze. In contrast, use of a breath shield alone without masking the patient resulted in droplets on the breath shield, slit lamp, table, and simulated examiner's neck. Of note, even when a surgical mask is worn properly by a coughing patient, droplet spread may still occur to the side bars adjacent to the slit-lamp chin rest [29[■]]. Aytogan *et al.* [33[■]] identified SARS-CoV-2 ribonucleic acid in a sample obtained from a slit-lamp breath shield and another sample from a phoropter following the ophthalmic examinations of 22 asymptomatic patients. Notably, investigators wiped the forehead and chin rests of the slit-lamp with 70% isopropyl alcohol, a common practice in the pre-COVID era. Although patients were wearing masks, efforts were not made by staff to enforce their proper usage. While infectivity of viral samples was not assessed in this study,

its results reinforce the need for the improved disinfection protocols (in addition to masks and breath shields) that are now a part of our 'new normal' [34[■],35[■]].

Unlike adenovirus and herpes simplex virus 1, SARS-CoV-2 transmissibility via the ocular surface remains equivocal [36[■]]. Nonetheless, glaucoma practices have widely adopted the use of disposable diagnostic instruments during the pandemic to avoid potential contamination [37[■]–39[■]]. Single-use instruments offer improved safety when compared with their reusable counterparts as the latter chance improper disinfection as well as damage from repeated cleansing and high-level disinfection [40]. Goldmann applanation tonometry (GAT) remains the gold standard for intraocular pressure (IOP) measurement. In a survey of the American Glaucoma Society membership conducted prior to the pandemic, 98% (193 of 197) of glaucoma specialists preferred GAT over other methods of IOP measurement, and 55% (109 of 197) were exclusively using single-use disposable GAT tips [41[■]]. Disposable GAT tips are available from multiple manufacturers (Tonosafe, Haag-Streit, Bern, Switzerland; Tonomate, Keeler, Ltd, Windsor, UK; Tonoclear, Keeler, Ltd, Windsor, UK; Tonojet, Luneau, Pont-de-l'Arche, France) and are cost-effective considering the additional expense associated with disinfecting reusable GAT tips [36[■]]. Disposable GAT tips demonstrate reasonable correlation with reusable GAT tips for IOP within the normal range [42–44] and are more reliable than alternative methods of contact tonometry, including Icare (Icare Finland Oy, Vantaa, Finland) and Tono-Pen (Reichert, Inc., Buffalo, New York, USA) [44], which employ disposable probes and tip covers, respectively. Icare and Tono-Pen exhibit wider 95% limits of agreement (–8.18–9.06 for Icare versus –8.55–5.21 for Tono-Pen) than disposable GAT (–3.35–4.96) when comparing each modality with standard GAT [44]. Icare and Tono-Pen are also more likely to overestimate the IOP in eyes with greater central corneal thickness (CCT > 555 μm) [45]. Glaucoma specialists who routinely use Icare or Tono-Pen should therefore exercise caution in eyes displaying extremes of IOP and/or CCT, as their results may erroneously influence clinical decision-making.

Ultrasound pachymeters with disposable tip covers are also commercially available (PalmScan Pachymeter, Micro Medical Devices, Inc., Calabasas, California, USA), as are single-use gonioscopes, laser iridotomy lenses, and selective laser trabeculoplasty lenses (Katena Products, Inc., Parsippany-Troy Hills, New Jersey, USA; Lombart Instrument Co., Norfolk, Virginia, USA; Volk Optical Inc., Mentor, Ohio, USA). Disposable ultrasound probe covers also exist

for ultrasound biomicroscopy (ClearScan, ESI, Inc., Plymouth, Minnesota, USA).

Several aspects of glaucoma care delivery have become safer for patients, physicians, and staff as a result of the pandemic. Such efforts will remain essential indefinitely in reassuring patients that their health and safety are being prioritized during visits to glaucoma practices [15[■],46[■]]. In addition, the use of disposable GAT tips and lenses will eliminate the need to perform high-level disinfection of reusable instruments and thereby confer ongoing benefits with regard to streamlined workflow, efficiency, and cost.

Streamlining in-person visits

Although minimizing wait times for patients was relatively straightforward when in-office censuses were low, maintaining efficiency became challenging as glaucoma practices returned to their prepandemic volumes. Patients are no longer willing to tolerate crowded waiting rooms and extended wait times [15[■]]. The need to incorporate new safety measures has demanded more time and effort from staff, and practices have had to develop more efficient models of glaucoma care to streamline in-person visits.

Multiple approaches have been adopted to reorganize patient flow and reduce the total amount of time patients spend in the office. Streamlining glaucoma care can begin prior to the appointment date by mailing new patient questionnaires to patients for completion at home or making forms available online. When scheduling in-person appointments by telephone, staff may also prescreen new and established patients by collecting a history of present illness, medical and ophthalmic history, medication lists, and other pertinent data [27[■],47[■],48[■]], and later confirming that no changes have occurred on the appointment day. An online check-in process or self-check-in at a kiosk can help alleviate queues at the office entrance [27[■]]. Unidirectional flow, aided by markings on the floor or wall, with one entrance for check-in and one exit for check-out, may expedite patient movement through the office and help to avoid congestion at reception and check-out areas [27[■],49[■]]. Suburban practices may ask patients to wait outside (weather permitting) or in their private vehicles until their appointment times, a common practice at the height of the pandemic [27[■],48[■],50[■],51[■]]. Bringing patients directly into an examination or testing room after check-in may help avoid crowding in the waiting room [27[■],48[■]]. Having the same technician who measures visual acuity and IOP also perform ancillary testing may streamline patient flow and reduce

the number of face-to-face encounters required for each patient [27[■]]. This strategy also minimizes the number of times patients must return to the waiting room between different aspects of their glaucoma evaluation. Patients can be offered separate appointments for testing and in-person consultation with their glaucoma specialist to minimize the amount of time spent in the office on a given day and utilize resources more efficiently. Technician-based testing can be performed on a day on which the physician is in the operating room or performs administrative duties.

Prior to the pandemic, some large, multispecialty practices, such as those based in a hospital or an academic setting, had imaging suites and diagnostic equipment on different floors of a given building. The pandemic compelled reorganization of such arrangements, such that equipment needed for a given subspecialty like glaucoma was consolidated onto one floor, limiting patient traffic between floors and saving time. Having administrative staff perform the check-out process and schedule the next visit while the patient is still in the examination room may avoid queues at the discharge desk. Planning in advance for any ancillary testing that will be required at the next appointment may also improve flow. In addition to these modifications, some practices have expanded office hours to include evenings and weekends, further minimizing wait times and helping to avoid crowded waiting rooms [34[■],48[■]]. Glaucoma specialists may consider widening follow-up intervals for glaucoma suspects and patients proven to have stable disease for many years, contributing to overall practice efficiency. Ninety-day medication prescription refills, where permitted by insurance companies, may help safeguard medication availability and decrease the number of phone calls to the office, thereby reducing demands on staff [37[■]]. Finally, collaboration among administrative staff, ophthalmic technicians, and physicians, sometimes expanding duties beyond one's typical responsibilities, has been instrumental in streamlining in-person visits for patients.

Implementing teleglaucoma

Use of telemedicine burgeoned during the early months of the COVID-19 pandemic, particularly when routine outpatient visits were suspended. Its implementation was supported by relaxation of regulatory barriers, including the removal of penalties for Health Insurance Portability and Accountability Act violations, elimination of geographic restrictions, and reimbursement parity during the Public Health Emergency (which, after several

renewals, remains in effect as of this writing). However, ophthalmologists were among the least frequent users of telemedicine during the early pandemic when compared with other physicians providing chronic care. In a database analysis of telemedicine use among 16.7 million beneficiaries with commercial insurance and Medicare Advantage over the first 13 weeks of the pandemic, Patel *et al.* [52[■]] observed that 9.3% of ophthalmologists used telemedicine at least once (versus 67.7% of endocrinologists and 50.0% of cardiologists), and only 2.6% of telemedicine visits were for glaucoma. While teleglaucoma has been used for years as a screening tool in remote and underserved areas [53], several barriers to its routine implementation for disease management exist [5[■],48[■],49[■],54[■]–61[■]]. Long-term glaucoma monitoring relies upon physical examination findings (e.g., IOP measurement, gonioscopy, optic nerve assessment) and extensive ancillary testing (e.g., CCT, perimetry, and imaging of the retinal nerve fiber layer and macula) [62[■]]. Currently available tools for home-based glaucoma monitoring, including rebound tonometry and remote perimetry, are either inadequately validated or limited by expense [54[■],56[■],57[■]]. Poor vision, lack of access to and familiarity with digital health platforms, and poor internet connectivity may also limit patients' ability to utilize teleglaucoma.

Nonetheless, teleophthalmology, and specifically teleglaucoma, have served a vital role during the pandemic [51[■],63[■]–70[■]]. Virtual visits have enabled continuity of glaucoma care during lockdowns, allowing physicians to reassure patients [51[■]], reinforce medication adherence, and provide counseling regarding management plans. Telephone and audiovisual consultations have also allowed ophthalmologists to triage patients requiring in-person visits versus those whose chief complaints are amenable to remote management [51[■],63[■]–70[■]]. Images of the eyes and ocular adnexa provided by patients via smartphone-based applications (e.g., WeChat [65[■]] and WhatsApp [68[■]]), when of sufficient quality, have permitted virtual diagnosis (e.g., topical glaucoma medication toxicity [69[■]]). In a cross-sectional, hospital-based study of teleconsultations performed in Tamil Nadu, India between April and May 2020, Ravindran *et al.* [68[■]] found that nearly half (47.7%) of 621 telephone calls were medication-related, of which 56 (9.0%) involved questions regarding alternatives to prescribed medications, largely for glaucoma.

The merits of teleglaucoma have been further harnessed during the pandemic through a hybrid model of glaucoma care delivery which combines in-person, technician-driven data collection with subsequent remote review by, or real-time virtual

consultation with, a glaucoma specialist [15[•],47[•],60[•],61[•],70[•],71[•]]. This innovative approach was instituted in the United Kingdom a decade prior to the pandemic in an effort to meet increasing demand for eye care that exceeded capacity within the National Health System (NHS) [47[•]]. Kotecha *et al.* described a stable monitoring service that provided hybrid glaucoma care to 1575 low-risk patients (i.e., glaucoma suspects and those with early-to-moderate glaucoma) between March 2014 and April 2015. Technicians assessed visual acuity, performed visual field testing, measured IOP, instilled dilating eye drops, and obtained optic nerve imaging before discharging a patient home. Within 2 weeks, a glaucoma specialist remotely reviewed data and made clinical decisions regarding follow-up. Total average time spent by patients in the hybrid clinic was 51 min, compared with an average of 92 min in the conventional glaucoma outpatient clinic [72]. Clarke *et al.* [73] observed infrequent disagreement between clinical decisions made by attending glaucoma specialists during virtual glaucoma visits and in-person visits, reporting misclassification events in two of 204 (0.98%) patients. Both patients who were inappropriately deemed to be stable via virtual visits but whose disease was found to be progressing during in-person visits in this study had advanced visual field loss, suggesting that teleglaucoma is best reserved for patients with early-to-moderate disease. A 2016 NHS survey of clinical and glaucoma leads found comparable patient acceptability, safety, and efficiency between virtual glaucoma clinics and standard outpatient visits [74].

In the COVID-19 era, the hybrid model has been adopted in various forms by glaucoma practices worldwide [15[•],70[•],75[•]]. At the height of the pandemic, some suburban practices implemented ‘drive-through’ IOP checks, in which patients remained in their vehicles and underwent rebound tonometry by a staff member wearing PPE, followed by virtual visits with their glaucoma specialists [15[•],75[•]]. Glaucoma practices have since continued to use a more sustainable strategy in which patients undergo any indicated diagnostic testing in-person with a trained technician and then review results by telephone or video visit on a later date with their glaucoma specialists. In some regions of the world, testing centers established in more remote areas have been used for the initial technician-based evaluations. Tham and associates recognized that 40% of patients within the Singapore National Eye Center’s glaucoma clinic had stable disease and could benefit from a hybrid model of care. The authors established Investigative Units in the Community at which patients with stable glaucoma and low-risk

glaucoma suspects underwent testing by technicians. Data were reviewed remotely by a glaucoma specialist within 1 week. Patients requiring a change in management were scheduled for a video visit and those whose management was to be continued were informed via short message service or e-mail. A majority of patients agreed that the new model provided efficient (90.2%) and satisfactory (94.8%) glaucoma care [70[•]].

In its current state, teleglaucoma is best reserved as a supplement to, rather than a replacement for, in-person visits. Its future expansion and sustainability will rely on numerous factors including favorable reimbursement structures, ease of use, acceptance by physicians and patients, and further validation of home monitoring devices. During the pandemic, both patients and providers have recognized the challenges inherent in providing completely virtual glaucoma care without the availability of ancillary testing [15[•]]. A hybrid model, which permits acquisition of critical data that cannot be gleaned virtually and reduces the amount of time patients spend waiting in the office, may represent a viable strategy for incorporating teleglaucoma in the post-COVID era if supported by payers.

CONCLUSION

The COVID-19 pandemic has supported a paradigm shift in the delivery of glaucoma care. Glaucoma practices worldwide have adopted innovative modifications to optimize safety and streamline in-person visits, many of which will persist indefinitely. Teleglaucoma has enabled the implementation of a hybrid model of care while tools for home-based glaucoma monitoring undergo further refinement and validation. Beyond the pandemic, these developments in care delivery will allow for improved access to services and a reduction in existing disparities within our communities.

Many unanswered questions remain regarding the long-term impacts of the pandemic on glaucoma care. Patients who have been unable to follow-up for extended periods continue to reestablish care today, often presenting with uncontrolled IOP and disease progression. As more data become available supporting the efficacy of selective laser trabeculoplasty, microinvasive glaucoma surgery, and sustained drug delivery devices, glaucoma specialists may shift their practice patterns toward earlier intervention to mitigate such adverse outcomes. Interestingly, reports from countries including India, Italy, and the United Kingdom have demonstrated a significant decrease in the number of trabeculectomies performed during the pandemic in favor of less invasive procedures, including

cyclophotocoagulation and microinvasive glaucoma surgery [76[■],79[■]]. The pandemic's influence on surgical trends in the United States has yet to be formally evaluated. Additional goals for improving glaucoma care in the post-COVID era include harnessing technological advances to identify our most vulnerable patients (e.g., those at risk for rapid progression), improve equitable access to care [59[■],61[■]], and promote health literacy through online platforms [46[■],80[■]], with a continued emphasis on safety and efficiency during in-person visits.

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Conflicts of interest

There are no conflicts of interest.

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