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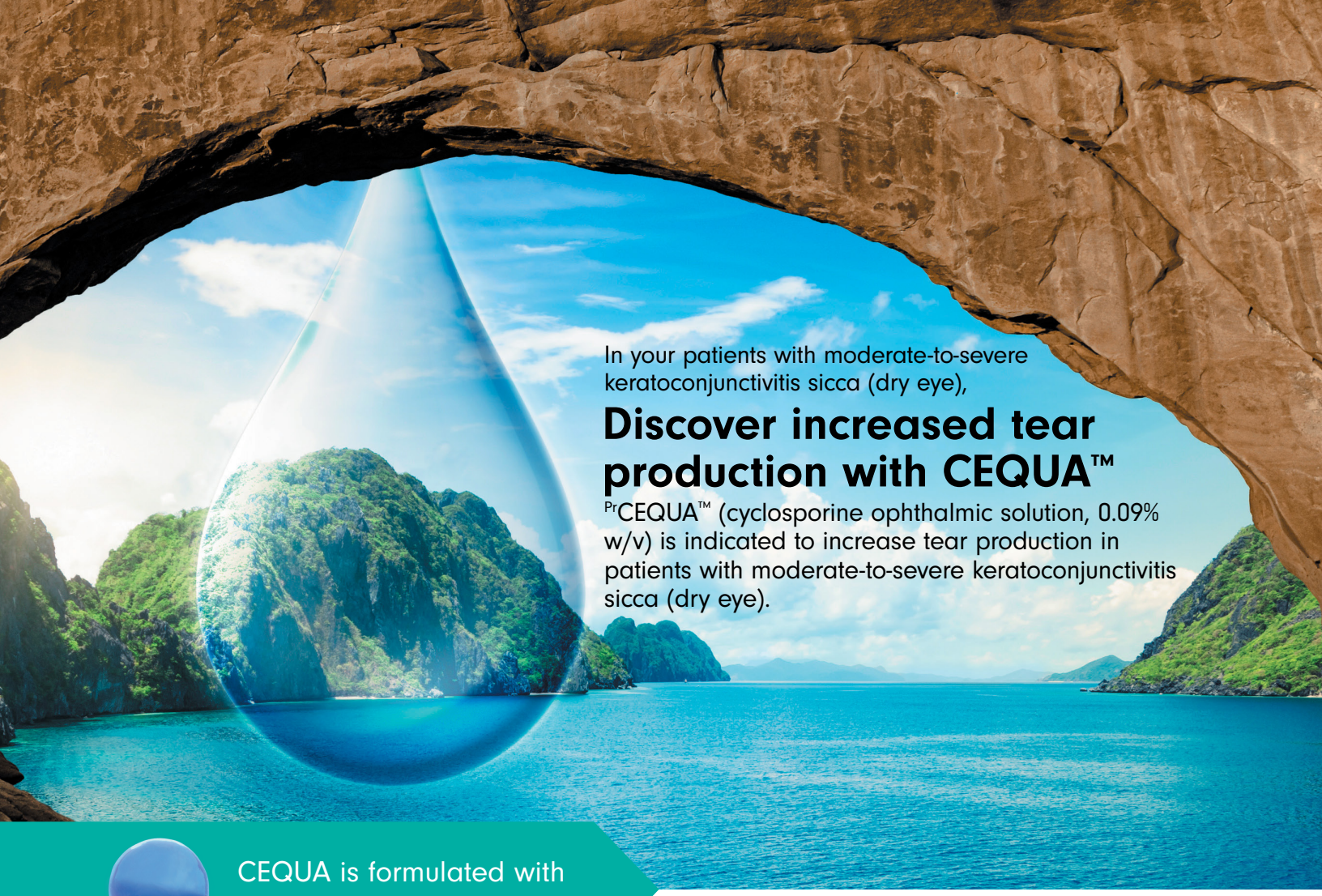

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Management of the Blind Eye and Options for Cosmesis

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Introduction

As ophthalmologists, our ultimate goal in the treatment of patients with eye conditions is the preservation of vision and the eye. However, there are conditions necessitating the removal of an eye for pain control; control of infection source; treatment of malignancy; severe trauma; perforated corneal ulcer; or cosmesis.[1] Over the years, there has been a shift in both surgical techniques and choice of implants, all with the goal to improve cosmesis outcome and decrease implant exposure and extrusion. However, there remains a wide range of approaches due to the variety of patient and disease factors. We present here an overview for how to think through the different aspects of eye removal and the subsequent cosmetic rehabilitation.

Enucleation vs Evisceration

The use of enucleation, removal of the entire eye including the scleral shell, or evisceration, removal of the ocular content and cornea, continues to be a topic of significant debate. A survey in North America and Asia found that fellowship-trained oculoplastic surgeons show a higher incidence of performing evisceration than enucleation.[2,3] However, some have advocated against evisceration in any patients with a blind, painful eye with no obvious cause to avoid inadvertent evisceration and seeding of occult malignancy.[4,5] Conversely, this risk can be mitigated with b-scan ultrasound in any patient without a clearly documented underlying cause for blindness to rule out possible malignancies prior to evisceration.

Persistent socket pain after eye removal has also been used as an argument for enucleation over evisceration. Despite earlier arguments for possible preservation of the sensory ciliary nerve although it continued to conduct pain following evisceration, later studies did not find a difference in chronic socket pain in patients undergoing evisceration compared to enucleation.[6,7] In a 2018 meta-analysis, the cause for persistent pain for more than a month following eye removal was attributed to phantom pain in 73% of cases.[8] More importantly, in 20% of cases there is an attributable underlying cause that may be correctable, such as prosthesis fit; dry socket; trochleitis; compression of the infraorbital nerve; implant infection or exposure; or neuromas. It is important for the clinician to explore these possibilities in patients with chronic pain following eye removal.

Sympathetic Ophthalmia

The risk of sympathetic ophthalmia (SO) has been an argument for enucleation rather than evisceration following severe open globe injury, even though the risk of SO is likely similar for any mechanism where there is uveal trauma or incarceration. In the only prospective study to date out of the United Kingdom, the risk of SO from all causes was found to be only 0.03/100,000.[9] Vitreoretinal surgery, especially with repeated surgery, may be as important a risk factor for the development of SO as trauma. The risk of SO was cited to be as high as 1 in 8,000 vitrectomies, where enucleation of the inciting eye did not lead to better visual outcome of the fellow eye.[9,10]

In eyes severely damaged by trauma with no visual potential, historically, early enucleation within 14 days was advocated in order to prevent SO. However, a meta-analysis of SO cases published over a 30-year period found that more of these eyes had enucleation (5.7%) after eye trauma rather than evisceration (3.2%).[11] Moreover, prophylactic removal of an eye to decrease the risk of SO, even in severe trauma, is not warranted.[12] Attempts should be made for primary repair of the globe whenever possible.

Endophthalmitis vs Panophthalmitis

In cases of endophthalmitis or panophthalmitis requiring eye removal, arguments have been made for enucleation rather than evisceration for the prevention of implant exposure or extrusion due to the remaining sclera as a source of residual infection. In cases of endophthalmitis without panophthalmitis, one can also argue that by not opening the globe, there is better containment of the infectious source with enucleation. However, in recent years there has been increased use of evisceration following treatment with broad-spectrum antibiotics, with a comparable implant extrusion rate of approximately 13%.[13] The risk for extrusion was related to the type of infection, specifically pseudomonas, but the pendulum favouring the use of porous vs non-porous implants continues to shift with time without one showing a clear increased risk of exposure or extrusion.[14,15]

Socket Movement

The removal of an eye, even when for chronic pain, can be psychologically overwhelming for patients. One fear for the patient is the potential for disfigurement and the lack of acceptance in society. In addition to prosthesis fit and movement, which are addressed below, socket movement contributes to the overall reality of the prosthesis. Note that the discussion of socket movement and prosthesis movement is separate as they are independent factors. Attempts at using surgical techniques to improve socket movement have included the use of porous implants especially with pegging. However, the long-term issue with foreign body reaction around the peg and subsequent exposure of the implant around the peg has led to pegging falling out of favour with most surgeons.[16,17] The surgical technique and choice of implant can impact the long-term complication rate. The combination of suturing the extraocular muscles to the fornices and use of a porous implant has been shown in a randomized trial to ensure optimal socket movement.[18] Even with the use of a non-porous implant, bringing the extraocular muscle to the fornix confers better movement to the socket than imbrication of the muscle above the implant, which is also believed to contribute to implant migration.

Prosthesis Fit

A well-fitted prosthesis can not only provide wear comfort for the patient; it is also important for cosmesis, an important aspect of overall patient quality of life following the removal of an eye. Without polishing and maintenance, a prosthesis can develop scratches and chips over time that can lead to socket conjunctival inflammation, increase discharge and cause patient discomfort. Aside from the inherent quality of the prosthesis, socket and lid factors also impact the wear of a prosthesis.

A healthy mucosal lining that is not keratinized is required for movement of the prosthesis and comfort

Figure 1. A) Front profile of an ocular prosthesis with an addition superiorly to help correct for ptosis. B) Side profile of prothesis showing thickness attempting to correct for deficiency in superior sulcus; courtesy of Marie Allen, BCO, BADO.

in wear. This may be challenging when the patient has had numerous prior ocular surgeries, prior radiation therapy or chemical injury. Buccal mucosal grafting and/or dermis fat graft may be needed at times to try to reconstruct a mucosalized socket lining. In cases of severe avascular socket where survival of mucosalized tissue is challenging, there may be a temptation to resort to skin graft for closure. Although this provides a lining for the socket, patients invariably complain of discomfort during prosthesis wear and complete lack of movement of the prosthesis. Anecdotal evidence has shown utility in pre- and/or post-operative hyperbaric oxygen therapy to facilitate retention of dermis fat graft in these difficult cases.

The socket volume also has an interplay with fornix depth, which is important for prosthesis retention. Socket volume plays a greater role in cases of shortened fornix secondary to insufficient orbital volume and deficiency in the “bulbar” conjunctiva rather than the palpebral conjunctiva. Augmentation of socket volume allows for the fornix to be reformed. True palpebral conjunctival deficiency is less common and is typically seen with chemical injury or trauma. Lid reconstruction with buccal mucosal or hard palate graft may be required in these cases to achieve sufficient fornix depth.

In addition to its role in fornix depth, socket volume plays a critical role in long-term prosthesis wear. When the volume of the socket is insufficient, the prosthesis needed is larger and thicker, making movement of the prosthesis more difficult; it also causes secondary stretch on the lids over time due to weight. Patients should be counselled that even in a well-sized prosthesis, increased stretch of the lids can occur over time, necessitating lid adjustment with ectropion repair or lid shortening of, most commonly, the lower lids and possibly even the upper lids.

Ptosis post-eye removal can be as high as 40% and may also be impacted by insufficient socket volume.[19] To correct mild ptosis, i.e., ≤ 1 mm, an addition can be made to the superior portion of the prosthesis (**Figure 1**). However, for larger ptosis, the use of this method will only aggravate the condition over time as the result of mechanical stress on the levator muscle. Some patients also find these additions to be painful to wear; additionally, they may decrease movement of the prosthesis. Ptosis repair with levator advancement with removal of these additions prior to surgery is advisable.

Lastly, prosthesis movement does require some additional room within the socket, especially with horizontal movement where closer distance already exists between the edge of the prosthesis and the orbital rim. An overzealous fill of the socket space when molding a prosthesis may result in a prosthesis that’s too large to allow for full movement. Simply decreasing the size of the prosthesis alone can improvement movement in these cases.

Figure 2. A) Front profile of a scleral shell showing the increased curvature vs a prosthesis. B) Under-surface of a scleral shell showing the thinner profile vs that of an ocular prosthesis; courtesy of Heather Meszaros, BCO, BADO.

Scleral Shell

In patients with a blind phthisical eye without pain, an alternative to eye removal can be the use of a scleral shell for cosmesis (**Figure 2**). A scleral shell is designed to be worn directly over a phthisical globe with an increased curvature over the cornea. However, for many patients the additional curvature makes the wear difficult. Some ophthalmic surgeons have suggested the use of lamellar keratectomy with a conjunctival flap to cover the ocular surface in order to help with the wear of a scleral shell.[20] The one significant downside to this approach is the subsequent difficulty of having sufficient conjunctiva for enucleation or evisceration should the eye start to become painful. In view of this, a scleral shell should only be considered when patients can tolerate it; otherwise, enucleation or evisceration should be considered instead.

Conclusion

The loss of an eye can be a difficult psychological journey for the patient even in the face of chronic pain. The choice of surgical technique needs to be individualized based on the underlying pathology and health of the remaining socket. A cosmetically ideal outcome for the patient depends on the interplay between socket, prosthesis and lids. Each of these components needs to be considered to achieve the optimal patient outcome.

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Ophthalmologists' Musculoskeletal Health: An Often Overlooked Concern

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Introduction

You may be familiar with the adage by Jim Rohn, "Take care of your body. It is the only place you have to live." This wise statement is of extreme relevance to clinicians as we do our best to manage growing waitlists and backlogs, diminishing healthcare resources, increasing patient demands, and the expectation to "do more with less."

Most of us were never prepared for the impact of these demands on our physical health, mental wellbeing and career longevity. Ophthalmologists, by virtue of the procedural nature of our specialty and the challenges created by the equipment and devices we use every day, are at high risk for work-related musculoskeletal disorders (WMSDs). According to the Canadian Center for Occupational Health and Safety, work activities that are frequent and repetitive or activities with awkward postures produce musculoskeletal disorders that may be painful during work activities or even at rest. These WMSDs are painful disorders of muscles, tendons, joints and nerves. Injuries can result from overuse and may develop over long periods of time.

How Common are WMSDs Among Ophthalmologists?

A 2018 systematic review and meta-analysis published in *JAMA* reported on WMSDs among surgeons and other clinicians. The review found that the prevalence of WMSDs among this group of at-risk physicians is *comparable to that reported among physical labourers* (**Table 1**)![1] In a 2005 survey of American ophthalmologists, 52% of the 697 respondents reported neck, upper body or lower back symptoms in the prior month; 15% of respondents reported having to limit their work as a result of their symptoms.[2] A survey published in the

Surgeons		Physical Labourers	
Neck	65%	Neck	32%
Shoulder	52%	Shoulder	28%
Back	59%	Back	54%
Upper Extremity	39%	Upper Extremity	42%

Table 1. 12-month prevalence estimates for work-related musculoskeletal pain; adapted from Epstein et al, 2018.[1]

Canadian Journal of Ophthalmology (CJO) in 2019 reported similar occupational musculoskeletal pain and injury in Canadian ophthalmologists.[3] Fifty percent of respondents reported musculoskeletal pain in the preceding 12 months associated with tasks performed in the clinic setting, while 48% reported occupational musculoskeletal pain in the preceding 12 months related to working in the operating room (OR). Neck pain was reported in 46%, lower back pain in 36% and shoulder pain in 28% of respondents.

Why are Ophthalmologists at High Risk?

Degenerative disease of the cervical or lumbar spine, rotator cuff pathology and carpal tunnel syndrome are the most common types of injuries reported by at-risk surgeons. This data might be puzzling as ophthalmologists don't lift heavy equipment or use hammers and power saws. One of the main reasons that ophthalmologists are at high risk is related to limited flexibility and adjustability of operating microscopes and slit lamps. This necessitates the user to adopt extreme or awkward postures in order to interface with equipment and patients. Excessive force or exertion and repetitive activities produce physical strain when working in the clinic and OR. According to the Canadian survey cited above, the most commonly reported challenges were related to performing repetitive tasks, working in cramped or awkward positions, and bending or twisting the neck.[3] The cumulative effect of these daily strains can take a serious toll over time. The following factors have been identified as leading to WMSDs in ophthalmologists:[4-6]

- Use of ophthalmic equipment and devices that have not been designed with surgeon comfort in mind
- Leaning forward at the slit lamp and craning one's neck to reach the oculars; referred to as the "slit lamp slump"
- Slit lamp controls are set relatively high up; therefore, exerting gripping forces on instruments or free lenses produces static forces on the shoulders as we try to keep our arms stable
- Excessive flexion of the elbows and wrists when using the slit lamp controls, causing us to sit in an awkward, uncomfortable position
- Extreme or awkward head and neck postures when examining patients with the indirect ophthalmoscope
- Pushing our head and neck forward in order to see through the oculars of the operating microscope
- Strain on the hips and ankles can develop when the phacoemulsification and microscope foot pedals are not level with one another

The static position of the head when looking through the microscope oculars can lead to spasm of contracted spinal musculature. Maintaining these positions can result in neck and back pain and related nerve problems including tingling in the hands. Over time, the awkward postures lead to the development of degenerative disc disease in the neck and/or lower back.

Slit Lamp Slump → Forward Head Position → Risk of Career-Ending Injury

Unfortunately, the examination equipment and devices we use repeatedly everyday promote a forward head position/posture (**Figure 1**). The forward head posture is characterized by neck extension which pushes the head forward beyond its natural position over the cervical spine. This posture places a strain on the muscles and bones of the neck and creates increasing amounts of weight pressure on the spine. It is not surprising that ophthalmologists experience cervical spine, shoulder and elbow pathology as we repeatedly look through oculars that don't tilt or telescope in or out and reach for knobs on the slit lamp that require us to lean forward and flex our unsupported arms.

Physician Heal Thyself?

When asked about pain management, the majority of Canadian ophthalmologists who participated in our 2019 survey reported relying on non-steroidal anti-inflammatory agents (NSAIDS), rest and massage therapy to manage pain secondary to work related activities.[3] The use of prescription opioids and need for surgical intervention were reported by a small minority of our colleagues (1.8% of respondents). Interestingly, ophthalmologists most commonly sought care from massage therapists (27% of respondents), followed by physiotherapists (15%); family physicians (14%); personal trainers (10%); sports medicine

- Damage from prolonged head forward position contributes to muscle spasms, disc herniation, osteoporosis and nerve impingement
- Posture impacts and modulates all body systems from breathing to hormonal production
- Spinal pain, headache, temporomandibular joint (TMJ) disorders, mood, blood pressure, pulse, and lung capacity are some of the symptoms and bodily functions most impacted by poor posture

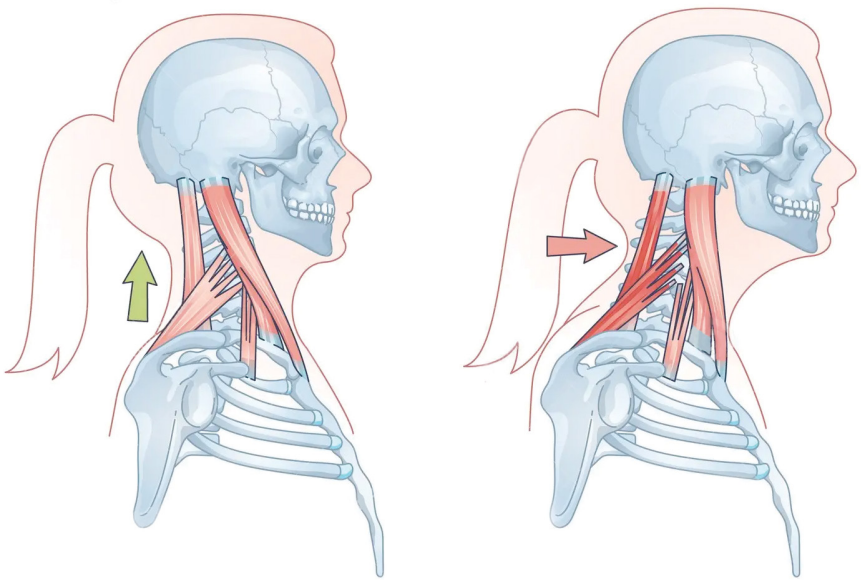

Figure 1. Forward head posture. Excerpted from Mayo Clinic Health Letter, March 2000.[7]

specialists (7%); neurosurgeons (3%); neurologists (2%); and physiatrists (3%).[3]

While massage therapy is a popular choice, consulting a physiotherapist, sports medicine specialist or physiatrist is a highly recommended first step. Neurological symptoms and deficits should not be ignored. These red flag symptoms require prompt assessment and investigation. Your family physician may need to refer you to a neurosurgeon, neurologist or orthopedic surgeon.

Regardless of the severity of pain or injury, ongoing physical conditioning is an essential part of self-care. A program that includes strength training, stretching and flexibility training is best undertaken with the guidance of a physiotherapist or registered kinesiologist. It is critical to consult with an *ergonomist* (either through the occupational health department at your hospital or a privately hired ergonomist) to assess your posture while you work, as well as the ergonomics of your workspace. The ergonomist can provide you with a customized ergonomic optimization plan for your specific needs.

It is clear that the solutions to the poorly addressed problem of WMSDs in ophthalmology do not lie in the realm of “physician heal thyself.” The solutions extend beyond our personal efforts to “sit up straight” or exercise five nights a week. Self-care is essential; however, even with the best self-care regimen, we return day after day to the same ergonomic challenges in our clinics and ORs. Without a doubt, physician-centric improvements in equipment and device design engineering will promote improved well-being and optimal career longevity for ophthalmologists.

The Impact of WMSDs

The impact of WMSD extends beyond physical pain, limited range of motion, weakness, reduced stamina, and other signs and symptoms. Numerous additional challenges exist:

- Cognitive: Musculoskeletal pain disrupts attention, sleep, and endurance
- Mental health: Anxiety and depression related to the negative impact of WMSD on career and personal life
- Burnout and moral distress: WMSD is associated with a high risk of burnout
- Patient care: Cancelled ORs and clinics, and even temporary changes in practice profile impact patient wait times and delivery of care
- Financial: Decrease in professional income, additional personal expenses related to rehabilitation and recovery
- Career-ending disability or early retirement
- Healthcare system: increase in wait times, lost productivity, cost of cancelled ORs and clinics, cost of replacing experienced and productive surgeons

Everybody is Susceptible to WMSDs

Less than a year ago, I experienced a work-related musculoskeletal injury. In my case, the perfect storm was in place for this to occur. I was the sole cornea specialist in the department, accepting additional referrals to compensate for three vacant full-time equivalent positions, while trying to manage my already full practice. My clinics were busy and when I was offered additional OR time, I took it to help manage my long surgical wait list. Unfortunately, one night while I was performing an emergency open globe repair, I felt significant pain in the back of my neck. I was able to finish the case; however, the following morning, the pain was much worse, and I was unable to turn my head. I had no choice but to take a brief medical leave. Fortunately, I did not require spinal surgery. I was advised to begin an intense rehabilitation program with a physiotherapist and registered kinesiologist. I also did some myofascial release therapy which was beneficial. It's important to remember that these injuries occur, not because we are reckless, but because we are so focused on delivering timely care, trying to make up for being short- staffed, and putting our patients and learners first. As a result, we often put ourselves last.

I returned to work determined not to re-injure myself despite returning to an even longer wait list and scores of appointments, minor procedures, laser surgeries, and surgeries to rebook. At the same time, I had to be committed to my own rehabilitation program. All of these challenges have given me a deeper perspective of the importance of advocating for and promoting physician wellness, both physical and mental.

My journey has also highlighted the critical role of individuals in leadership positions in their capacity to support physicians with WMSDs. Whether we work in a hospital setting, academic institution or private centre, it is critical for leaders to understand the importance of and facilitate the clinician's gradual return to work with the necessary ergonomic accommodations and improvements in the OR, clinic and office workspaces. Bear in mind that the process of ergonomic optimization is iterative and involves multiple trials and assessments. The reality is, prioritizing the procurement of ergonomically optimized ophthalmic equipment will benefit all stakeholders in the healthcare system.

I am fortunate to have resumed work and I'm well on the way to functioning at my pre-injury level. I am at the point in my recovery that I can share my personal experiences with my colleagues and our future ophthalmologists so that they can take proactive steps to avoid experiencing a work-related musculoskeletal injury.

Fulfilling the Needs of Ophthalmologists and Patients: Is it Really Possible to Achieve Both?

Consider these innovations:

Stereoscopic heads-up 3D imaging systems for cataract and posterior segment surgery

Rather than looking through the eyepieces of a microscope, heads-up surgery allows the surgeon to view the procedure on a large monitor. The surgical video and images are created by a 3D camera attached to the microscope. Heads-up surgery promotes a straight back posture for the surgeon which helps keep the spine in a more neutral position, avoiding the forward head posture.

Several systems have been developed, including the NGENUITY® 3D from Alcon, Zeiss Artevo 800, Beyeonics One from Beyeonics, and the SeeLuma™ from Bausch + Lomb. Some of these systems, however, require a head turn posture in order to visualize the 4K monitor. This is because the monitor cannot be positioned directly in front of the surgeon. Additionally, if the surgeon prefers to use the eyepieces for visualization, the conventional oculars create the all-too-familiar ergonomic challenge of the forward head posture. One notable exception is the SeeLuma visualization platform that is designed to allow surgeons to look straight ahead at a monitor without having to turn or twist the neck. Its innovative, ergonomically designed eyepieces can also be angled up and down as well as telescoped toward the surgeon. Based on its ergonomic design alone, I believe this platform has the potential to revolutionize ocular surgery.

The continuously adjustable inclined slit lamp microscope head

Interestingly, the slit lamp design has not changed in over 100 years. Although this "timeless design" seems to persist, Marco slit lamps (Takagi; by INNOVA) are available with a continuously adjustable eye piece

that can help reduce head and neck strain (**Figure 2**). The eyepieces extend further than those of the conventional non-adjustable slit lamp oculars and can be angled from zero to 90 degrees. This instrument will be available in Canada in the near future.

Figure 2. Image of Marco slit lamp; Takagi Europe.[8]

Conclusion

Physician-centric ergonomic innovations have the potential to improve our well-being and career longevity while enhancing patient outcomes. It is imperative that Canadian ophthalmologists are attentive to the potential for WMSDs and proactively seek to address concerns so as to minimize long-term impact on their health and patient care.

Financial Disclosures

None declared.

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ABOUT THE PANELISTS

Moderator

W. BRUCE JACKSON, MD, FRCSC: Dr. Bruce Jackson is an ophthalmologist who specializes in cornea and external diseases and refractive surgery. In 1986, he became Ophthalmologist-in-Chief at the Royal Victoria Hospital and in 1987, Chairman of the Department of Ophthalmology at McGill, Program Director, and Research Director. He held the position until 1991, when he moved to the University of Ottawa and became Chairman of the Department of Ophthalmology and Director General at the University of Ottawa Eye Institute, The Ottawa Hospital until the end of his mandate, in June 2008. He is the recipient of the Canadian Ophthalmological Society and the Eye Physicians and Surgeons of Ontario's Lifetime Achievement Awards.

SETAREH ZIAI, MD, FRCSC: Dr. Setareh Ziai is an Assistant Professor of Ophthalmology at the University of Ottawa Eye Institute. She completed her residency training in ophthalmology at the University of Ottawa Eye Institute, followed by two years of fellowship training in cornea, external disease, anterior segment, and refractive surgery. Her practice encompasses tertiary care clinical and surgical ophthalmology, with a focus on ocular surface disease, corneal transplantation, ocular tumour resection, anterior segment reconstruction and complex cataract surgery. She is heavily involved in clinical research, as well as resident and fellow surgical and clinical training. She is the Director of the Cornea, Anterior Segment & Refractive Surgery Fellowship Program, as well as the Director of the Ophthalmic Medical Technology training program at the University of Ottawa Eye Institute. She is also a founding member of Canadian Women in Medicine and a member of the Canadian Ophthalmological Society Board of Directors.

GUILLERMO ROCHA, MD, FRCSC, FACS: Dr. Guillermo Rocha is Medical Director of the Ocular Microsurgery & Laser Centre in Brandon, MB. He trained in ophthalmology at McGill University in Montreal and has completed subspecialty training in ocular immunology and inflammation (McGill University), and cornea and external diseases (University of South Florida, Tampa). He completed the Physician CEO Executive Program at the Kellogg School of Management, Northwestern University in Chicago, IL in 2016. He is Professor of Ophthalmology at the University of Manitoba, President of the COS Foundation, past President of the Canadian Ophthalmological Society (2016-2018), past President of the Canadian Cornea, External Diseases and Refractive Surgery Society, and former Head of the Department of Surgery at the Brandon Regional Health Centre (2004-2009). In the Canadian Ophthalmological Society, he is a past Board Member and past Chair of the Council on Continuing Professional Development.

DOMINIQUE BOURRET-MASSICOTTE, MD, FRCSC: Dr. Dominique B. Massicotte is a comprehensive ophthalmologist and Department Head at CIUSSS Capitale-Nationale, Quebec. She is currently an Assistant Professor at Laval University, in charge of the Ethics Course in Ophthalmology and a Wetlab instructor focused on challenging cataract surgeries. She was invited to speak about her experience on starting a new department at the first Next Gen meeting in San Diego. Passionate for continuous refinement in cataract surgery, she was part of the faculty during the Canadian Ophthalmology Society Co-Developed Symposium, sharing pearls on the management of challenging surgical cases. Finally, while as a resident she helped create the annual All About IOLs symposium, she is now a faculty member dedicated to empowering the residents to better understand intraocular lens choices.

HALL CHEW, MD, FRCSC: Dr. Hall Chew received his MD from Dalhousie University and completed his Ophthalmology residency at the University of Toronto. He then completed a Cornea, External Disease fellowship at the Wills Eye Hospital in Philadelphia, PA. He is a Professor in the Department of Ophthalmology & Vision Sciences at the University of Toronto.

Maximizing the Ocular Surface Prior to Ocular Surgery: An Expert Roundtable Discussion

W. Bruce Jackson, MD, FRCSC
Setareh Ziai, MD, FRCSC
Guillermo Rocha, MD, FRCSC, FACS
Dominique Bourret-Massicotte, MD, FRCSC
Hall Chew, MD, FRCSC

Dry eye disease is common as people age, and it's often asymptomatic. Ensuring the best outcomes, safety and patient satisfaction for cataract and other ocular surgeries requires careful examination and step-wise treatment of ocular surface disease.

Bruce Jackson (Moderator): When we look at The Prospective Health Assessment of Cataract Patients' Ocular Surface (PHACO) study, it revealed that most people who underwent cataract surgery had some degree of ocular surface disease. In the study, among patients with a mean age of 71, 60% to 87% with dry eye disease were asymptomatic. However, more than 70% had a tear breakup time (TBUT) of less than five seconds and 77% corneal staining. Improving the ocular surface is necessary to determine whether patients indeed need surgery, and which surgical option will result in the best outcome.

In your practice, how important is it to examine the ocular surface prior to surgery?

Setareh Ziai: We know that ocular surface disease is more common in women, and with aging. We also know that much of cataract surgery happens in the older population. Lastly, we know that a poor ocular surface can affect short- and long-term outcomes of surgery. Knowing those facts makes it undeniable that we need to properly assess the ocular surface before any type of ocular surgery.

Guillermo Rocha: With the advent of premium lenses, it is imperative to address the ocular surface. We noticed that the measurements that we took for intraocular lens implants prior to cataract surgery were not always accurate. In addition, people would say that they could read for a few minutes and then their vision "goes away." Or they would comment that they can watch TV or drive, but when they blink, their vision can become blurry. In these cases, ocular surface disease, rather than cataracts, is what's impairing a patient's vision.

Dominique Massicotte: I often ask patients to describe their eye challenges in their own words. Often, they tell me about redness in their eyes or eye fatigue. It's important to ask about their symptoms in detail because, in some cases, moving forward with cataract surgery could exacerbate their symptoms. At the slit lamp, I like to quickly measure the tear meniscus and breakup time and then look for rosacea and meibomian gland dysfunction.

How do you treat the ocular surface prior to surgery?

Hall Chew: I encourage warm compresses and preservative-free artificial tears. If there is ocular surface inflammation, I may suggest low-dose steroids, while making sure that patients don't have any issues with infection or pressure spikes. Then, I'll have patients come back after 2–4 weeks to recalculate. Sometimes I do serial calculations to see if I can find consistency. It can be important to make patients aware of the variability, and the challenges that this poses for cataract surgery.

G.R.: We send letters to patients outlining specific lid hygiene routine, even before patients come into the office. We suggest warm compresses every day, tea tree oil cleansing, and artificial tears as needed. Many of the patients come in having already done this before they see us for an assessment. We tell patients to continue performing this routine until the time of surgery and then to start again one week post-surgery.

S.Z.: Some patients only need a little bit of what I like to call "TLC": Teaching them about increased humidity and less screen time, Lubrication, and Compresses. I also recommend Omega-3 supplements.

B.J.: What about the patient that has mild lid disease, rapid tear breakup and significant corneal staining. Would you delay surgery to improve the surface?

D.M.: I would treat the patient with artificial tears, ideally without a preservative. I really like gel at night. I also ask patients about how they heat their homes—wood-burning heat is especially drying—and I recommend a humidifier accordingly. If the ocular surface has improved three to four months later, I repeat the biometry. I make sure that patients continue their efforts until the surgery, explaining that the surgery will be better tolerated by them and easier for me.

H.C.: Patients don't like to delay surgery, so communication is very important. It's important to set the expectation that dry eye disease may be more symptomatic as they heal after cataract surgery, and as they taper off steroids. This helps to reinforce the importance of taking the time for good eye hygiene.

B.J.: The literature suggests that treating patients with a steroid, cyclosporine, or both, can improve the post-operative outcome, if the patient has keratitis associated with dry eye. This is something I do in my practice. Do you do this as well, with more severe dry eye patients?

S.Z.: As we get into more advanced dry eye, I bring cyclosporine, oral tetracycline, and punctal occlusion into my therapeutic armamentarium, depending on the severity of the case and the underlying cause. I also use a short course of a steroid drops for about one month before measurements and surgery. This is not ideal for long-term treatment, but it reduces some of the inflammation in order to improve our measurements and maximize our surgical outcomes.

H.C.: It's important to use steroids, when necessary, but also to explain the importance of tapering off the steroids, because chronic use can lead to glaucoma.

G.R.: If we see a significant amount of keratitis, I will use cyclosporine ahead of surgery.

B.J.: Is there anything you do differently in the operating room for patients with dry eye disease?

G.R.: We use a wick for dilating patients, so we're not always adding drops, which makes patients more comfortable.

D.M.: After the surgery, I like to put a pressure patch on those patients with severe dry eye disease and have them sleep with it the first night. This seems to lower patients' pain, because they don't open their eyes, and they don't have their eyelid rubbing on the surface that has ultimately dried during the surgery.

H.C.: I also patch the eye for patients after surgery. I usually see patients a few hours later, as my patients often tend to be discharged on the same day. When I check their eyes, I don't usually put another drop of topical anesthetic in, because that can further dry the eye. In addition, when preparing for surgery, I only put the anesthetic in the surgical eye. If you anesthetize both eyes, the blink rate will be reduced in both eyes.

B.J.: Let's discuss a case. A 73-year-old male was referred for possible cataract surgery. His only complaint was decreasing vision over the past year. The initial examination revealed ocular rosacea with meibomian gland disease, 20/30 and 20/40 best corrected vision, a rapid tear breakup and central epithelial basement membrane dystrophy (EMBD) lines as well as inferior superficial punctate keratitis in both eyes. How do you manage this patient?

S.Z.: I would treat the ocular surface with the TLC method I mentioned earlier and oral doxycycline or minocycline. I would also treat the EBMD with phototherapeutic keratectomy. I would expect the vision to improve significantly after these treatments, and the patient may not end up needing cataract surgery at this point. We really can't tell until we clean things up because the surface is so poor and affecting the vision in ways we cannot measure.

D.M.: Again, I would start by asking the patient to describe his symptoms. He likely thinks his red eye and burning are from his cataract, and that the surgery will fix the problem. I would explain that the ocular surface problems are separate from the cataract issue, and that he has to put effort into treating the ocular surface. I would encourage eyelid hygiene and artificial tears, and then I would start doxycycline on the second visit. If the tear film and surface hasn't improved by the third visit, I would address the EBMD with a superficial keratectomy or a PTK.

H.C.: After optimizing the ocular surface, the patient may be happy with their vision and comfort level. It makes the risk-benefit decision regarding surgery more straightforward for the patient.

G.R.: This is one of the most common complex cases I see. I divide my treatment approach for these patients into two steps. First, I focus on fully treating the meibomian gland dysfunction with lid hygiene,

doxycycline, fusidic acid, and lubricating drops. I bring them back three months later, and do a superficial keratectomy. I use anesthetic, betadine, and then a lid speculum, and use a couple of dry cotton tip applicators to peel off the EBMD. I then do the biometry after another month. It's very rare that I do a phototherapeutic keratectomy on patients with EBMD.

B.J.: I also always treat EBMD before considering cataract surgery. I have seen two to three lines of improvement come just from superficial keratectomy or PTK. However, I would suggest waiting longer, as I've seen the refraction change up to three months post-operatively.

What about patients with Salzmann's nodular dystrophy? Do you proceed with cataract surgery, or do you first remove these and let the cornea heal?

S.Z.: Topography is always helpful in knowing how much a Salzmann's nodule is affecting the vision and more importantly, the visual axis. I treat most cases of primary Salzmann's nodules prior to cataract surgery. Recurrent nodules can be trickier to treat, and are sometimes left in place, assuming they are small and relatively stable.

G.R.: We first treat the ocular surface. Then, when they come back, we peel off the nodules at the slit lamp. I take Colibri forceps and move the epithelium around, find the edge, and they simply just peel off. You don't even have to do a complete keratectomy. After a few weeks, we remeasure them.

H.C.: I usually do the removal in the treatment room, but if the treatment room is being used, we will do the removal at the slit lamp.

B.J.: What about pterygium prior to cataract surgery?

S.Z.: I would excise most pterygia prior to cataract surgery. The exception would be a very small and peripheral pterygium in an elderly patient. If the lesion is not affecting the visual axis or the corneal curvature, and has looked the same for the past 40 years, it is unlikely to become an issue anytime in the future.

H.C.: Unfortunately, you can see surgically induced necrotizing scleritis (SINS) post pterygium excision, and we recently saw a patient with a perforation as a result of surgery. So, you have to be careful with pterygium removal. But if it's affecting the vision, with no signs of corneal scleral thinning and/or rheumatological disease, it's reasonable to proceed with removing it.

G.R.: If there is significant astigmatism, especially more than 1.25 or 1.5 diopters, I would remove it.

B.J.: Do you manage patients differently if they have other corneal lesions, scars, or dystrophies, and may also have cataracts?

S.Z.: You want to ensure that keratoconus and pellucid marginal degeneration are as stable as possible prior to surgery. I would not treat other corneal conditions, such as difficult-to-treat dystrophies, small scars and early Fuchs' dystrophy. In all cases where a corneal pathology is being left untreated prior to cataract surgery, it is of utmost importance to manage the patient's expectations prior to surgery. They should know that the outcome is not guaranteed, that they may need glasses post-operatively and that their corneal condition (and thus their vision) could change over time.

H.C.: I try to avoid penetrating keratoplasties, given the risks involved with them, compared to the endothelial and lamellar transplants we can now perform. One tip I've incorporated into my practice is to use the medium setting of your light filter, make the beam very broad and look straight on. That will mimic the operating room view. If you think you can safely do the cataract surgery with that view, then you should go ahead.

B.J.: This has been a very helpful discussion, highlighting the importance of thoroughly examining (not just looking at the tear meniscus), and treating the ocular surface prior to surgery. Do you have any final takeaway points?

D.M.: I would say that artificial tears are your best friend, pre-operatively and post-operatively. I always prescribe artificial tears the second month after surgery. This keeps the patient comfortable and precludes the need for many phone calls to our clinic.

H.C.: I would like to underscore the importance of avoiding the use of topical nonsteroidal anti-inflammatory drugs (NSAIDs), in patients with significant dry eyes and possible rheumatological disease which may lead to catastrophic events (i.e., corneal perforations, thinning, and scarring). Always consider that patients who have significant ocular surface disease and keratitis sicca, may have underlying rheumatologic issues (i.e., rheumatoid arthritis, Sjogren's syndrome) which can lead to permanent vision loss when topical NSAIDs are used.

G.R.: In 2022, we have very good lenses and biometers for cataract surgery. The drawback is that if we don't get good data, the results will be poor. So it's necessary to optimize the ocular surface. Keratometry readings are one of the two most important variables in calculating lens powers.

ABOUT THE AUTHOR

XAVIER CAMPOS-MÖLLER, MD: Dr. Xavier Campos-Möller is head of the Glaucoma and Advanced Anterior Segment Surgery division of the Department of Ophthalmology at Western Memorial Regional Hospital in Corner Brook, Newfoundland, since 2016. Dr. Campos-Moller is a graduate of the Glaucoma and Advanced Anterior Segment Surgery fellowship with Dr. Ike Ahmed at the University of Toronto. He currently runs a practice in Corner Brook, Newfoundland, focusing mostly on cataract, complex anterior segment, and glaucoma surgery. Dr. Campos-Moller is councilor for the Canadian Glaucoma Society and an active member of the Canadian, American and Mexican Ophthalmological Societies as well as the American Society of Cataract and Refractive Surgeons and the European Society of Cataract and Refractive Surgeons. He has lectured in multiple countries, published over 20 scientific papers in the fields of cataract, anterior segment surgery and glaucoma, and also recently published a best-selling book: Illustrated Advanced Anterior Segment Surgery. He is committed to the eradication of blindness and frequently travels overseas for humanitarian surgery missions, having performed thousands of surgeries for those in need. He is currently the president of SeeLevel, an organization committed to providing ophthalmic surgery to those that need it most.

Environmental Impact of Ophthalmology and Related Action Plan: Sustainability Inside and Outside of the Operating Room

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Climate Change and its Impact on Health

Climate change, global warming, or “global weirding” as some experts call it, is now undeniable. Extreme weather events such as flash floods, fires and hurricanes are increasing in both frequency and intensity. These changes are directly influenced by a changing climate as a by-product of greenhouse gas emissions, principally but not exclusively carbon dioxide (CO_2) and methane (CH_4).[1]

In 2021, the Canadian town of Lytton, British Columbia was destroyed by wildfires following three days of record-breaking heat with temperatures rising as high as 49.6°C. This represented an abnormal event that could potentially become frequent if greenhouse emissions are not controlled. Oceans are particularly sensitive to global warming (more than 90% of excess environmental heat is accumulated in the oceans) and they directly contribute to weather patterns due to their close interaction with the atmosphere. The

year 2022 was the hottest year in history for our oceans, even surpassing the previous year's record maximum.[2] According to a South American report, in 2022 children under one year of age were exposed to 2.35 million more person-days of heatwaves each year vs data from 1996–2005.[3]

Plastics production has increased twenty-fold over the past 50 years, from 15 million tonnes in 1964 to 311 million tonnes in 2014.This number is expected to rise exponentially. Plastic packaging represents 26% of the total volume of plastics used. Of this plastic packaging produced, 95% or $80–120 billion USD annually, is not able to be recycled following a short single use.[4]

To further complicate the issue, plastic waste degrades into microplastics (particles under 5 mm in size) and nanoplastics (< 1 µm) when exposed to natural forces such as sunlight and wave action. In vivo studies have demonstrated that nanoplastics can translocate to all organs and there is a growing body of evidence linking micro- and nanoplastic exposure with cellular toxicity, and a likely detrimental effect on health.[5]

Although the effects of microplastics and nanoplastics on human health are not yet fully understood, there is evidence to support the occurrence of increased inflammation, oxidative stress and apoptosis, as well as deleterious effects on metabolic homeostasis.[6] Furthermore, plastics can severely affect the health of fish populations, directly impacting individuals whose diet and economy depend on fishing.[5,6]

Some of the health effects of climate change are easily now detectable. Their risk and intensity will increase proportionally with the magnitude of climate change. In fact, it has been postulated that the elimination of fossil fuel utilization would prevent approximately 3.6 million premature deaths per year globally from air pollution.[7,8]

Additional effects of climate change and their repercussions on human health include:[9]

- Temperature extremes: Higher incidence of heat-related deaths and medical visits for cardiovascular (CV), kidney and respiratory disorders
- Floods: Increased drowning deaths and higher exposures to mold and waterborne diseases
- Wildfires: Poor air quality increases respiratory and CV issues such as asthma and chronic obstructive pulmonary disease (COPD)
- Air pollution: Exposure to particulate matter and ozone increases hospitalizations and deaths due to respiratory diseases such as asthma
- Allergens and pollen: Longer growing seasons produce more pollen and increased incidence of allergies

Ocular manifestations of climate change include:[10]

- Increase in UV-radiation-related pathology (pterygium, cataract, age-related macular degeneration (AMD), intraocular and extraocular melanomas, carcinomas)
- Increase in allergies and ocular surface disease from air contaminants
- Increase in malnutrition-related eye disease from devastation of our ecosystems and difficulty in obtaining food
- Increase in waterborne illness (pseudomonas, acanthamoeba)
- Increase in traumatic eye injuries and burns caused by natural disasters and fires

Ophthalmic Surgery and Climate Change

The healthcare sector is responsible for approximately 5% of Canadian greenhouse gas emissions. Although carbon dioxide is by far the largest emission by mass in Canada, our healthcare system also generates life cycle emissions of more than 210,000 metric tonnes of pollutant emissions (other than CO_2). These air, water and soil pollutants can be hazardous to humans.[11,12]

Cataract surgery is among the most common procedures performed worldwide. Morris et al reported that phacoemulsification performed in the United Kingdom can produce a staggering 182 kg of CO_2 equivalents ($KgCO_2e$) in the form of plastic waste per eye, which is comparable to driving an automobile for 500 km.[13] Plastic waste in cataract surgery is a significant problem that needs to be addressed.

Perhaps we must reconsider the paradigm that this excessive waste production is justified by reduced infection rates. Current evidence suggests that excessively wasteful practices do not reduce endophthalmitis rates. In 2019, the Aravind Eye Hospital demonstrated that simply by using intracameral moxifloxacin, their endophthalmitis rates declined to 0.04%,[14] the same rate reported in the United States IRIS registry during the same period (2011–2018). However, there is a significant difference between the two settings: the Aravind Eye Hospital re-used, re-sterilized and re-purposed

so many of their "single use" supplies (e.g., saline bottles, blades, cannulas, gloves, surgical gowns, and gloves) that they were able to provide 60% of the two million surgeries reported for free, to those in need. In fact, if the Aravind Eye Hospital were to dispose all supplies after every case (as we commonly do in Canada), the emissions from each of their surgeries would be equivalent to 13 of their current surgeries.[15] The necessary question is: What evidence is there to support that full body drapes, changing gowns, gloves, phacoemulsification tips, and fluidics hoses/cassettes decrease our endophthalmitis rates? Unfortunately, there is no such data. These practices are traditions passed on to us by previous generations; they are habits adopted and sanctified at a time when the concept of evidence-based medicine (EBM) was unknown. We have been practicing "eminence-based medicine" at the cost of our environment's health and without true proven benefit to our patients. This practice of overaction in the name of safety has been termed "defensive medicine" and, unfortunately, it increases the cost per case and worsens the environmental impact of our procedures without improving outcomes.[16]

We need to start making decisions about safety and consider our impact on the environment based on evidence, not eminence. As some cynics have stated: clinical experience can be described as "making the same mistakes with increasing confidence over an impressive number of years.[17]

Is the Ophthalmology Sector Concerned?

Actually, ophthalmologists and nurses do care. According to a survey published by Chang et al in 2020,[18] the vast majority of ophthalmologists (90%) are concerned about global warming, feel that operating room (OR) waste is excessive, and wish there were more reusable options. In fact, if given the choice, ten times more surgeons would prefer a reusable product over a disposable one. Furthermore, there was a strong consensus regarding the need for manufacturers to reduce their carbon footprint with more environmentally conscious packaging and by modifying the "single use" labels to allow for surgeon discretion in deciding the lifespan of some products. This included ophthalmic drops, intraocular solutions, phacoemulsification and irrigation/aspiration tips, cassettes, and cannulas. Furthermore, most respondents reported that they wanted their medical societies to advocate for sustainability.

What Steps can be Taken?

Education

A significant change to our current approach is required in order to shift the direction in which we are headed. This should encompass a combination of widespread, small scale, individual changes and large-scale industry standards modifications, coupled with updated legislations issued by regulatory bodies.

Healthcare professionals (HCPs) must re-define the status quo, and research is the tool for this to occur. One example of this is the research by Mamalis et al, which showed that phacoemulsification tips are not ultra-structurally affected by multiple re-sterilization cycles.[19] Exploring the situation in less developed countries where expense reduction is obligatory may be a good way to study outcomes and safety, such as with the Aravind Eye Hospital. In fact, during the COVID-19 pandemic, the Hospital was forced to "regress" to the model that we currently use in North America (including excessive personal protection equipment [PPE], disposables, changing gloves). Interestingly, their infection rates did not decrease during this time.[20]

Educating ourselves, our peers and our policy-makers is fundamental. The author recommends joining Eyesustain.org, an organization endorsed by the American Academy of Ophthalmology (AAO), and the American and European Societies of Cataract and Refractive Surgeons (ASCRS and ESCRS). Their website contains numerous resources to support HCPs in making a change today. Start by calculating your OR's carbon footprint and modify your protocols and materials accordingly (https://eyesustain.org/topics/sustainability-in-the-operating-room/carbon-footprint-calculator). Reduce your custom cataract pack by requesting that they include only the essential items (eliminate excess cannulas, syringes, balanced salt solution [BSS] bottles). Not only is this practice sustainable, but it will also actually result in a cost saving for your institution. Re-purpose everything that was not used or did not come into contact with patients. The author sets aside any extra drapes, containers and disposable towels, and encourages staff to bring them home, extending their lifespan beyond the trash can.

Engage with your hospital management and encourage them to adopt more sustainable practices and materials. The Eyesustain.org library contains many articles that can be referred to when engaging

hospital committees and provincial or national regulatory bodies. Educate yourself and spread the knowledge with everyone around you. Contribute to the growing body of evidence by publishing your own results. Raise the sustainability conversation at your next ophthalmology meeting, regardless of its size. Encourage the organizing committees of ophthalmology meetings to increase the meeting content related to sustainability at their events. Additionally, consider choosing your in-person meetings wisely: A single scientist's carbon footprint can be as high as 2–5 tonnes of CO_2 per meeting (attributable to congress-related emissions such as travel, hotels, catering, event disposable materials, promotional materials, etc.).[21] We learned a tremendous amount about emissions and virtual meetings during the COVID-19 pandemic, it is now time to apply this knowledge.

Strength in Numbers

At some point we all need to become more involved. Large-scale change requires us to act as a group, especially when it comes to confronting the ophthalmic industry about unsustainable practices (e.g., packaging, shipping, labelling), and governments about policies and regulations that lack scientific evidence to support them. We must pressure the industry to increase the adoption of reusable packaging and industrially compostable plastic packaging for targeted applications, as well as reusable options. Governments should be encouraged to reduce the leakage of plastics into the environment. Moreover, manufacturers must be made accountable for after-use collection and reprocessing, particularly of products with high leak potential.[4]

Personal and Professional Responsibility

Life exists outside the OR, as does sustainability. As we become aware of our carbon footprint in healthcare facilities, it is important that we evaluate our personal lives with the same scientific rigour that we employ at work and ask ourselves what more (or less) can we do for our planet.

For education and excellent advice on more sustainable living, visit the United Nation's website and download their ActNow app, which provides a guide for living sustainably and empowering individuals to take action against climate change.

Summary

Climate change is a very real phenomenon and we have reached a critical point in time. Healthcare is a major contributor to emissions and climate change. We have a commitment to care for the wellbeing of humanity; this includes taking care of the environment in which we all live and on which we all depend. Most importantly, what we do today will determine our children's future. Action is required today; tomorrow will be too late.

Financial Disclosures

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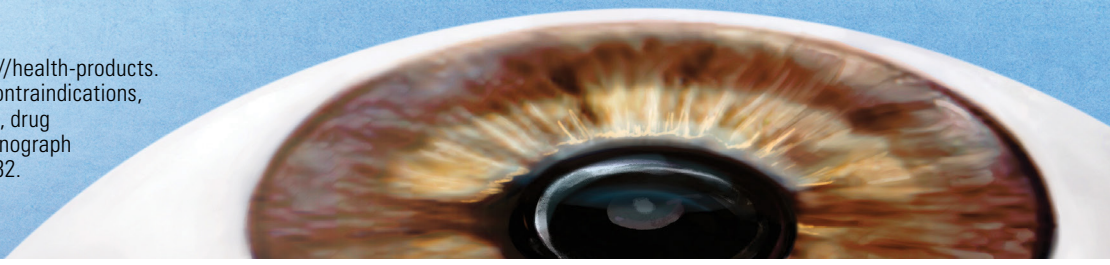

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Clinical Indications for Advanced Scleral Lenses

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Introduction

The origins of scleral lenses date back to the early 20th century when ground glass was used to manufacture scleral shells to improve vision, and to protect and support the ocular surface.[1] More than 120 years later, current scleral lenses are used for the same general purposes of sight restoration and ocular surface rehabilitation. Today's scleral lenses are made of highly breathable polymers allowing them to be worn successfully for multiple hours in a day.[2] Furthermore, our access to sophisticated technology allows for the production of highly customized and reproducible lenses (**Figure 1**).

Today's Scleral Lens Wearer

One of the primary indications for a scleral lens fit is to improve visual quantity and quality in patients with the potential for acuity gains.[3-6] For patients diagnosed with corneal ectasias such as keratoconus;

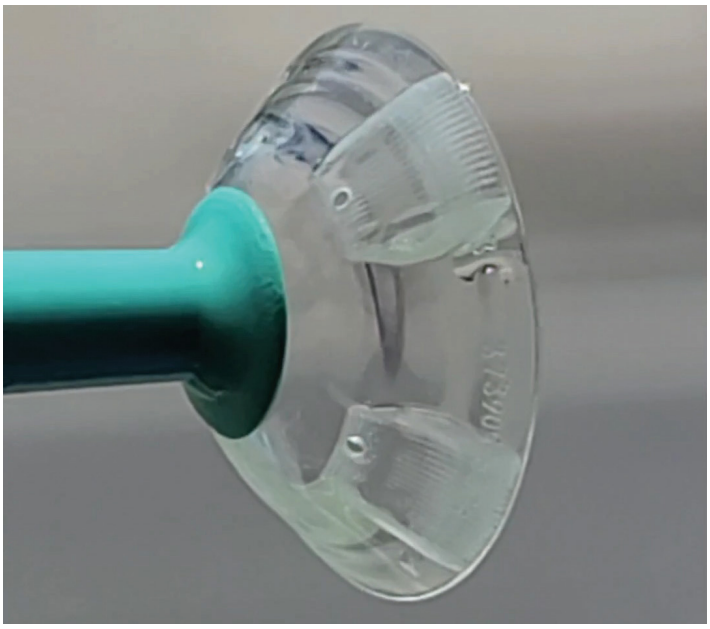

Figure 1. A custom scleral lens designed with channels and fenestrations to optimize lens wear for a post-penetrating keratoplasty patient with 20-year-old graft tissue; courtesy of Dr. Stephanie Ramdass.

Lens Use	Improve Visual Function	Relieve Ocular Discomfort	Rehabilitate Ocular Surface
Clinical Indications	• Keratoconus • PMD • TMD • Post-LASIK ectasia • Post-RK ectasia • Post-PK • Post-traumatic scar • Aphakia • High refractive error (including oblique astigmatism)	• Stevens-Johnson syndrome • Ocular cicatricial pemphigoid • Keratoconjunctivitis sicca • Sjögren's syndrome • Exposure keratopathy	• Limbal Stem Cell Deficiency • Neurotrophic keratitis • Chemical burns • Graft-versus-host disease

Table 1. Indications for fitting a custom scleral lens; courtesy of Dr. Stephanie Ramdass.

pellucid marginal degeneration; Terrien's marginal degeneration; post-refractive surgery ectasia; and post-keratoplasty astigmatism, spectacle lenses offer minimal improvement in visual function. A true scleral lens is fit large enough to completely vault the corneal surface so that the underlying tear reservoir can neutralize the uneven refracting surface. The anterior surface of the scleral lens then becomes the new smooth refracting surface. Patients with ectasia report drastic improvements in quality of life (QOL) due to significant increases in visual acuity and contrast sensitivity.[7,8] Many patients can finally seek meaningful employment, return to work, and successfully pass driving tests.[9]

The most rewarding patients to fit with scleral lenses are those seeking relief from ocular discomfort. Patients with a history of Stevens-Johnson syndrome and ocular cicatricial pemphigoid have constant pain due to mechanical dysfunction with each blink from keratinized lid margins. Trichiasis and chronically inflamed deficient conjunctival tissue result in desiccation of the corneal epithelium and a loss of corneal tear film homeostasis. These patients habitually live in the dark and spend most of their days with their eyes closed. They often enter the examination room wearing darkly tinted sunglasses. Often immediately after trial scleral lenses are inserted, the patient can raise their head to meet the clinician's eyes as the lens protects the delicate ocular surface from continuous microtrauma.[10,11]

In patients with conditions involving aberrant corneal wound healing such as limbal stem cell deficiency, graft-vs-host disease or neurotrophic keratitis, larger diameter scleral lenses (i.e., > 18 mm) known as prosthetic replacement of the ocular surface ecosystem (PROSE) help to support the ocular surface and stabilize or reverse the negative sequelae associated with these conditions.[12,13] When appropriately fit and worn as directed, scleral lenses have not been reported to lead to regression of corneal neovascularization and corneal opacification over time.[14] **Table 1** summarizes the most common clinical indications for fitting a scleral lens based on the category of lens use.

Optimizing the Scleral Fit

There are several methods to fit a scleral lens; however, the key step is to understand the ocular surface involved. A thorough case history, including charting current and previous ocular medications, is important to achieving fitting success. In the case of a diagnostic scleral lens fitting, topography and tomography scans are needed for all patients with irregular ocular surfaces in order to understand the distribution of the corneal astigmatism and to determine corneal elevation differences. These two factors assist in selecting the correct sagittal depth of the first trial lens (**Figure 2**).[15,16] A measurement of the horizontal white-to-white or visible iris diameter will help to select the correct scleral lens diameter of the initial trial lens. Alternatively, a scleral lens can be ordered empirically via impression-based technology whereby a mold using ocular non-toxic material is taken of the eye; a manufacturing lab then employs instrumentation that takes a 3D scan of the mold to create a highly customized first scleral lens.[17] Ocular surface profilometry is another tool that can greatly reduce chair time by accurately mapping out the lumps and bumps of the ocular surface via sophisticated software algorithms. This technology also results in the ability to empirically order a scleral lens.

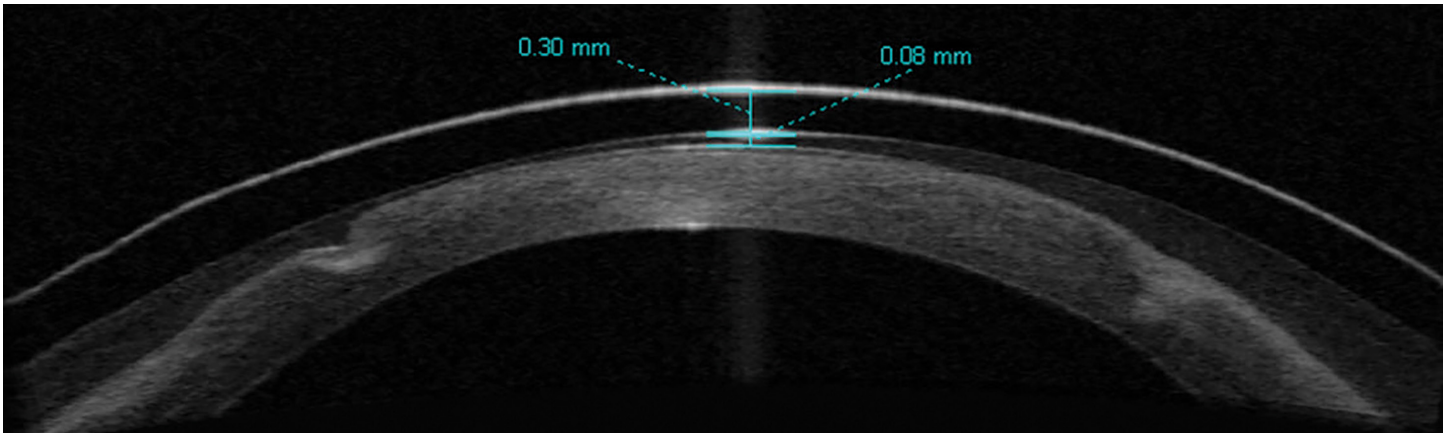

Figure 2. An anterior segment OCT cross-section that highlights a lens thickness of 300 microns and an insufficient amount of clearance of the lens over the irregular corneal surface; courtesy of Dr. Stephanie Ramdass.

In addition, it is important to photo-document the patient's scleral lens journey. Before applying a scleral lens on a patient's eye, baseline ocular staining with fluorescein or lissamine green with anterior segment photography are helpful not only to educate patients on their condition but also to monitor the impact of the therapeutic lens fitting over time.

Scleral Lens Wearer Triumphs and Challenges

As impactful as scleral lenses are when initially dispensed to patients, there are some situations in which the initial excitement wears off. In patients with ectatic disease, correcting irregular astigmatism and higher order aberrations can present a trade-off. Despite efforts to maximize visual acuity with spherical and sphero-cylindrical over-refraction, during follow-up visits patients may complain of ghosting or shadows around images they see.[18,19] An aberrometry measurement overtop the scleral lens when worn can aid in the understanding of any residual high-order aberrations (HOAs).[20] At the forefront of scleral lens research is custom HOA correction to advance visual acuity from good to great. While this technology is costly due to the high level of customization in these types of scleral lenses, some patients are seeking this cutting edge technology.

In patients with ocular surface disease, the fluid filled chamber that vaults over the entire corneal surface provides a soothing bath of moisture to alleviate chronic corneal pain symptoms. However, a scleral lens is still a large piece of plastic that the lids must blink over in order to maintain visual function. The most difficult scleral lens fit is in patients with tear-deficient conditions who are able to see 20/20 during their baseline scleral lens consultation visit or who require a high level of visual acuity throughout the day. A scleral lens can initially be life-changing for these types of patients; however, they are often plagued by poor wettability of the scleral lens surface, protein deposits that are not cleared from the front of the lens with each blink, and fogging of the tear chamber.[21] This can lead to a visual decline and, in some patients, results in discontinuation of lens wear.

There are several clinical contraindications to scleral lens wear. In patients with corneal graft tissue that has low endothelial function (less than 1,000 cell/mm^2), wearing a scleral lens can result in corneal edema and ultimately graft rejection.[22] Localized epithelial bullae can be observed while a scleral lens is worn. These findings can be seen as a negative staining pattern when fluorescein is applied to the ocular surface after lens removal.[23] Despite using highly permeable scleral lens materials to optimize health of the corneal surface, decreasing the volume of the tear chamber laying beneath the scleral lens surface, and modifying the scleral lens fit to include customizations such as channels or fenestrations, some of these patients will only be able to wear their scleral lens for a limited period during the day or not at all.[24] These types of eyes should undergo a wear-time challenge during their initial scleral lens dispense, where the patient is observed at T=1, 2 and 4 hours post-scleral lens insertion. This provides a clinician with insights into the compatibility of the compromised ocular surface with an overlying scleral lens. Should this fail and the corneal edema persists, the patient should be referred to a cornea specialist for consideration of an endothelial keratoplasty.

Co-Management Considerations

Some patients undergo partial or complete tarsorrhaphy in an attempt to save the ocular surface and preserve sight. Scleral lenses are an excellent alternative to protect the cornea and conjunctival tissues while restoring cosmesis for patients. During the scleral consultation visit, if it is determined that a patient can benefit from a scleral lens fit, a report to the referring surgeon or oculo-plastics specialist can include a request to open up the lids and increase the aperture opening. This provides the patient with a chance to achieve success with scleral lens insertion and removal.

Another anatomical limitation is the presence of symblepharon that limits successful scleral lens wear.[25] While a scleral lens can be notched to accommodate for this obstacle, symblepharon release with a mucus membrane graft can allow a patient to better insert their scleral lens and increase their lens wear time during the day (**Figure 3**).

Lastly, as a scleral lens rests with a footprint on the conjunctival surface, the presence of conjunctivochalasis can result in discomfort with lens wear over time. This loose tissue can get sucked toward the limbal border, contributing to a phenomenon called conjunctival prolapse, or can bunch up along the edge of the scleral lens.[26] If the scleral lens cannot be modified to accommodate for this redundant conjunctiva, the excess tissue can be cauterized. Scleral lens wear can resume once the surgeon has determined that the treated area is sufficiently healed.

Conclusion

Scleral lens fitting is rewarding for clinicians and even more so for patients who are thankful for a renewed sense of self-confidence and a drastic improvement in their quality of life. There are several clinical indications where a scleral lens can be used, as discussed above; however an astute fitter will understand when simply vaulting over the ocular surface is not in the best interest of the patient, and advanced customizations are warranted. The science of scleral contact lenses is continually evolving and utilizing advanced skills and technology are important to identify the correct modifications needed to optimize a scleral lens fit. As developments occur, situations that result in scleral lens failure can be minimized.

Figure 3. The presence of a symblepharon can limit the successful insertion and comfortable wear time of a scleral lens. Customizations, such as decreasing the diameter or notching the lens, can prevent direct contact with the conjunctival scar tissue; courtesy of Dr. Stephanie Ramdass.

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