

CJO RCO

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RECHERCHE

Aberrations du front d'onde chez des porteurs de LC souples asphériques et des porteurs de LC sphériques

RESEARCH

Wavefront aberrations in subjects wearing soft aspheric CL and those wearing spherical CL

RESEARCH

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RECHERCHE

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Optometrists played a key role at the Pan American Games in Toronto this summer.

Photo by Richard Andoga

This issue marks the end of the first year of the revamped CJO*RCO. Overall, it has been a positive experience for the editorial team and we have been encouraged by the comments from you, our readers. Thank you for your support.

Although summer is traditionally a time to relax and recharge after the hectic winter and spring months, it can also be very busy. For me, the CAO Congress was not only a chance to meet colleagues to chat about the CJO*RCO, but also an opportunity to visit with friends and classmates whom I have not seen in a while. I would like to thank the Congress organizers for the excellent job they did in mixing business and leisure time throughout the week. It made for a very enjoyable time in Fredericton.

I also spent 6 days providing eye care services at the PanAm and ParaPanAm Games in Toronto in July and August. The health care services that are provided to the athletes and their support teams at international sports events like these games is one of their best-kept secrets. The polyclinic that was set up in the Athletes' Village in downtown Toronto featured not only a fully equipped eye clinic and optical dispensary, but also a dental clinic, physical and massage therapy rooms, emergency surgical facilities and a MRI and CT facility – essentially a small hospital in a temporary building for the 6 weeks that athletes were on site. Many athletes and coaches get much of their health care at the PanAms, Olympics and World Championships this way. Talking with the athletes, coaches, trainers and medical support staff from the different countries was very interesting. My encounters with the para-athletes were particularly inspiring. Optometrists and ophthalmologists volunteered their services to staff the eye clinic throughout the period, and spectacles and contact lenses were dispensed without charge until the budget and time ran out.

My summer travels ended with an invited presentation to the American Astronomical Society's Solar Eclipse workshop in Portland, Oregon on eye safety planning for the 2017 total solar eclipse. On 21 August 2017, a total eclipse of the Sun will be seen along a track starting at the Oregon coastline in early morning, running southeast through Memphis and through the Carolinas into the Atlantic Ocean in late afternoon. Almost all of Canada south of the Arctic Circle will experience a partial solar eclipse. Just as for the eclipse of February 1979, the CAO will need to mount an eye safety campaign so that the Canadian public can view this astronomical event safely. Fortunately, my work on the ISO Technical Subcommittee on Eye Protection has included publication of an ISO standard on filters for direct viewing of the Sun which means that we will have certified safe viewing devices available to the general public.

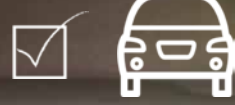
This issue has an interesting mix of articles on clinical subjects along with some helpful tips on practice management. I hope you will enjoy them.



B. Ralph Chou, MSc, OD, FAAO
Editor-in-Chief

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1. Kiss et al. Comparison of ultra-widefield fluorescein angiography with the Heidelberg Spectralis® \noncontact ultra-widefield module versus the Optos® optomap. Clin Ophthalmol. 2013, 389-94.

2. Silva, Cavallerano, Sun, Noble, Aiello. Nonmydriatic Ultrawide Field Retinal Imaging Compared with Dilated Standard 7-Field 35-mm Photography and Retinal Specialist Examination for Evaluation of Diabetic Retinopathy. American Journal of Ophthalmology, 2012.

3. Data on file

4. Silva, Cavallerano, Haddad, Kwak, Dyer, Omar, Shikari, Aiello, Sun, Aiello; Ophthalmology, 2015

Le présent numéro marque la fin de la première année de la CJO*RCO améliorée. Dans l'ensemble, l'expérience a été positive pour l'équipe de rédaction, et les commentaires que vous, nos lecteurs, avez formulés nous ont encouragés. Merci de votre soutien.

Même si l'été est habituellement un moment pour se détendre et refaire le plein d'énergie après un hiver et un printemps mouvementés, cette saison peut aussi être très occupée. Pour moi, le Congrès de l'ACO était non seulement une occasion de rencontrer des collègues pour discuter de la CJO*RCO, mais également de rendre visite à des amis et des confrères de classe que je n'avais pas vus depuis longtemps. J'aimerais remercier les organisateurs du Congrès pour l'excellent travail qu'ils ont accompli afin de combiner les affaires et les loisirs tout au long de la semaine. J'ai passé un moment très agréable à Fredericton.

J'ai également passé six jours à offrir des services de soins oculovisuels aux Jeux panaméricains et parapanaméricains à Toronto en juillet et août. Les services de soins de santé offerts aux athlètes et à leurs équipes de soutien dans le cadre d'événements sportifs internationaux comme ces jeux sont l'un des secrets les mieux gardés. La polyclinique qui a été mise sur pied dans le village des athlètes au centre-ville de Toronto comprenait non seulement une clinique et un dispensaire d'examen de la vue entièrement équipés, mais également une clinique dentaire, des salles de physiothérapie et de massothérapie, des installations chirurgicales d'urgence et des installations d'imagerie par résonance magnétique et de tomodynamométrie. Il s'agissait essentiellement d'un petit hôpital établi dans un établissement temporaire pour les six semaines où les athlètes se trouvaient sur place. Bon nombre d'athlètes et d'entraîneurs reçoivent ainsi une grande partie de leurs soins de santé durant les Jeux panaméricains, les Jeux olympiques et les championnats mondiaux. Il était très intéressant de discuter avec les athlètes, les entraîneurs, les instructeurs et le personnel de soutien médical de divers pays. Mes rencontres avec les athlètes paralympiques ont été particulièrement inspirantes. Des optométristes et des ophtalmologistes ont offert leurs services bénévolement afin que la clinique d'examen de la vue dispose du personnel nécessaire durant toute la période, et des lunettes et des lentilles cornéennes ont été offertes sans frais jusqu'à épuisement du budget et du temps.

Mes déplacements estivaux se sont terminés par une présentation sur invitation lors d'un atelier sur les éclipses solaires de l'American Astronomical Society à Portland, en Oregon, sur la planification de la sécurité des yeux en prévision de l'éclipse solaire totale de 2017. Le 21 août 2017, une éclipse solaire totale se produira, suivant une trajectoire débutant sur la côte de l'Oregon tôt le matin, puis se déplaçant vers le sud-est en passant par Memphis et les deux Carolines, jusqu'à l'océan Atlantique en fin d'après-midi. La presque totalité du Canada au sud du cercle polaire arctique assistera à une éclipse solaire partielle. Comme pour l'éclipse de février 1979, l'ACO devra mettre sur pied une campagne de sécurité des yeux afin que le public canadien puisse observer cet événement astronomique en toute sécurité. Heureusement, mon travail au sein du sous-comité technique de l'ISO sur la protection des yeux comprenait la publication d'une norme ISO sur les filtres pour l'observation directe du soleil, ce qui signifie que nous pourrions mettre à la disposition du grand public des dispositifs de visualisation sûrs et certifiés.

Le présent numéro comprend une combinaison intéressante d'articles sur des sujets cliniques ainsi que certains conseils utiles sur la gestion de la pratique. J'espère qu'il vous plaira.



B. Ralph Chou, M. Sc., O.D., F.A.A.O
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Written by Julien Goyard Ruel, O.D. in response to « Diverses modalités de traitement des troubles d'apprentissage scolaire par thérapies visuelles : quelles sont les évidences scientifiques. » by the optometrists Amélie Ganivet and Isabelle Denault, and the ophthalmologists Rosanne Superstein et Nicole Fallaha. Published in the Canadian Journal of Optometry in december 2014.

After reading the article, it seems to me that there is some incompatibility between the complexity of the subject and the point of view used to get to conclusions. In learning disorders, it is very hard to define the point where normal turns into pathologic. The complexity of the disorders prevents the possibility of isolating one variable from the other as well as of simplifying the treatment concept sufficiently to apply it uniformly to all individuals. With the obvious presence of unexplained visual symptoms in learning disorders, is it a responsible approach to discourage the few professionals who are interested in clinical possibilities?

The precise causes of dyslexia are, for the moment, hypothetical. We suppose that there is a genetic element involved but nobody can deny the importance of environmental influences. In addition to the phonological theory, observations support theories including cerebellar dysfunction and implication of the magnocellular pathway. Since these are influenced by vision, why would we deny interest coming from the disciplines of ophthalmology and optometry? Diagnosis of dyslexia requires a significant delay in development as well as other delays before the involvement of available therapy. If the optometrist can train the involved systems before it is shown to be problematic, it is hard to admit that he should not.

Conclusions in the last part of the article appear contradictory. It is said that precocious detection is essential. Is it not one of the vision care professional's responsibilities to evaluate reading capacity? Should we not encourage optometrists to get involved in multidisciplinary teams who do the evaluations? It is also said that the learning-disabled children should be redirected to the appropriate therapist. It would have been interesting to define who are the said appropriate therapists and what the optometrist should do in order to make sure that his patient has access to those resources. It is also repeated that cycloplegic evaluation is important to rule out any significant hyperopia. Does that mean that diminishing visual effort will help when dylexic manifestations are found? We could also note the fact that almost all the treatments of the binocular system are unproven. Strabismus surgeries, as an example, imply high cost to society but have not been proven better than placebo. Should we reconsider them then? The article concludes that it is recommended for visual therapies to be justified scientifically. By whom and how can such justification be developed if it is not recommended for optometrists to include them in their practice?

There is no obligation for teaching institutions and hospitals to get involved in every single subject concerning their field of practice. Despite this, those institutions have the power to chose which specializations will be taught to future workers. Does that mean that they should standardize the practice done outside their walls? Can they discredit research about whose foundation they remain largely uninformed? Many practitioners are reported treating successfully learning disorders using concepts linking ocular proprioception, spatial localisation and body balance. This science is, more than ever, a part of higher education in various countries like the United States or France.

There is no vision without movement. It is true concerning the retina. It is true concerning development of the brain. It is also true for our profession. Any discipline that fails to involve its members in the search for new possibilities, that fails to encourage them to be curious and creative, will not survive. Theory that the optometrist has to interpret each day needs to be adapted to each patient case. Can we afford to wait, without exception, for our tools to be

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In March 2014, we were deeply saddened by the passing of our colleague Dr. David McKenna.

David will be remembered for many things but mostly for his personality and his ability to make people laugh. I am sure each of you has fond memories of David.

David loved optometry and he worked hard at the provincial and national level to bring positive change to the profession. David was Prince Edward's representative to the Canadian Examiners of Optometry and served to the Canadian Examiners of Optometry and served on the CEO Executive Committee. He was a Trustee of the Canadian Optometric Trust Fund from 1988-1991, Chair of the CAO Congress in 1993 and Co-Chair of the 2009 CAO Congress in P.E.I. Provincially he was part of the executive committee for his entire career and he worked on the steering committee for provincial TPA's. He was host and a mentor to many optometry students from the University of Waterloo, and generously shared his knowledge and his home to some of the students. David believed strongly in the future and growth of optometry as a profession.

He devoted much time and effort to COETF. It was David's love for optometry that brought together a number of his friends and colleagues to set up a memorial fund in his name. We are an ambitious group with a goal to raise \$75,000.

David was a leader in his profession and contributed to the betterment of the profession for his entire career. By making a donation in his memory you will ensure that the spirit of David's generosity continues. COETF is optometry's only charitable organization and the funds raised are used to support optometry research and to provide grants to assist optometry students. We are asking for your support and a donation of \$1000 in David's name. If this suggested amount is not possible, please give, as you are able. You can donate online by visiting: www.coetf.ca



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submitted to large-scale studies before using them? Asking the question is answering it. The survival of a population depends on its diversity. Why would some people nip ideas in the bud? The article would seem to be more political than scientific. Let us stay aware in order to keep open minds allowing for expansion in our practice. We maybe have the potential to help young patients who have to face what are undeniably limited resources to cope with their disorders.

Julien Goyard Ruel, OD

Montreal, QC

Rédigé par Julien Goyard Ruel, OD, en réponse à « Diverses modalités de traitement des troubles d'apprentissage scolaire par thérapies visuelles : quelles sont les évidences scientifiques. » par les optométristes Amélie Ganivet et Isabelle Denault, et les ophtalmologistes Rosanne Superstein et Nicole Fallaha. Article paru dans la Revue canadienne d'optométrie, en décembre 2014.

Suite à la lecture de l'article, il me semble y avoir discordance entre la complexité du sujet abordé et l'angle utilisé pour tirer des conclusions. En ce qui a trait aux troubles d'apprentissage, la frontière entre pathologie et normalité est encore mal définie. La nature complexe des désordres à traiter ne permet pas toujours d'en isoler une composante et de simplifier le traitement au point de pouvoir l'appliquer à chaque individu de manière uniforme. Constatant l'association fréquente de symptômes visuels avec les troubles d'apprentissage, est-il responsable de tenter de décourager les quelques professionnels qui s'intéressent aux possibilités cliniques?

Les causes de la dyslexie demeurent pour l'instant hypothétiques. On suppose une part génétique, mais on n'exclut pas l'influence de l'environnement. Outre la théorie phonologique, on suspecte des implications dans les systèmes cérébelleux et magnocellulaires. Ces deux derniers étant influencés par la vision, pourquoi ne pas voir l'intérêt manifeste pour l'optométrie et l'ophtalmologie? Le diagnostic de la dyslexie demande près de deux ans de retard et d'autres délais sont nécessaires pour obtenir sans frais les soins disponibles. Il ne faut pas non plus oublier les nombreux patients qui rapportent devoir faire des efforts exagérés en lecture, mais qui n'auront jamais accès aux ressources orthophoniques parce qu'ils n'auront pas de diagnostic. Si l'optométriste a le pouvoir d'entraîner les systèmes suspects dès les premiers symptômes afin d'améliorer l'efficacité visuelle, difficile d'admettre qu'il ne doit pas le faire.

Les conclusions de l'article conduisent à plusieurs questionnements. On dit que la détection précoce de la dyslexie est essentielle. N'avons-nous pas une responsabilité concernant l'évaluation des capacités en lecture? Pourquoi ne pas encourager l'optométriste à s'impliquer dans l'équipe multidisciplinaire qui fera l'évaluation? Il est aussi dit qu'il faut référer les enfants limités dans leur apprentissage vers les professionnels appropriés. N'aurait-il pas été intéressant de mieux définir ces ressources et d'expliquer aux optométristes comment en faire profiter leurs patients? D'autre part, les auteurs répètent l'importance de la cycloplégie afin d'exclure toute hypermétropie significative. N'est-ce pas admettre que la diminution de l'effort visuel peut être nécessaire à l'efficacité de la prise en charge des manifestations dyslexiques? En ce qui a trait aux données probantes, il est aussi important de noter que l'ensemble des traitements touchant la binocularité sont très difficiles à prouver scientifiquement. On peut prendre l'exemple des chirurgies de strabisme. Elles comportent certains risques et sont coûteuses pour la société. Devrions-nous les reconsidérer tant qu'elles

ne seront pas soumises avec succès à des études contre placebo? Enfin, l'article se termine en disant qu'il est recommandé que les thérapies visuelles soient scientifiquement justifiées. S'il est déconseillé aux optométristes de les inclure dans leur pratique, comment est-ce réalisable?

Les institutions d'enseignement et les hôpitaux n'ont pas l'obligation de s'intéresser à toutes les sphères impliquées dans le domaine qui les concerne. Ils ont le pouvoir de choisir les spécialisations qui seront enseignées aux futurs travailleurs. Mais la question se pose, ont-ils le droit de tenter d'uniformiser la pratique lorsque cette dernière ne se fait pas à l'intérieur de leurs murs? Devraient-ils faire preuve de réserve avant de discréditer certaines idées dont ils connaissent peu les principaux fondements? De nombreux succès cliniques sont rapportés par des professionnels de la vision tenant compte des principes du sens de l'équilibre, de la proprioception oculaire et de la localisation spatiale. Ces concepts sont enseignés dans plusieurs universités, notamment en France et aux États-Unis.

Il n'y a pas de vision sans mouvement. L'idée peut s'appliquer aux influx nerveux rétiniens. C'est aussi vrai concernant le développement du cerveau. Ce l'est tout autant pour une profession, qui doit voir sa pratique selon différents angles pour mieux faire face à l'avenir. Si elle n'arrive pas à susciter la curiosité et la créativité de ses membres, elle ne pourra traverser le temps avec succès. La survie d'une population dépend de sa diversité. La théorie que l'optométriste doit interpréter chaque jour doit être adaptée à chaque cas unique rencontré. Peut-on attendre, sans exception, que les moyens disponibles soient soumis à des études à grande échelle? Poser la question c'est y répondre. Pourquoi donc vouloir ainsi supprimer des avenues pleines de potentiel? L'article, ainsi que certains choisis en référence, pourraient donner l'impression d'être mus par des motifs politiques plutôt que scientifiques. Soyons vigilants à préserver l'ouverture d'esprit qui nous permettra d'étendre nos champs de pratique. Nous avons le potentiel d'aider de jeunes patients qui possèdent, quoi qu'on en dise, des ressources limitées pour s'adapter aux désordres qui les touchent.

Julien Goyard Ruel, OD

Montréal, QC



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Aberrations du front d'onde chez des porteurs de LC souples asphériques et des porteurs de LC sphériques

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<https://opto.ca/document/wave-front-aberrations-soft-aspheric-contact-lenses>

to read an English version of this article

Sommaire

Objectif : Mesurer le niveau des aberrations d'ordres supérieurs (AOS) lors du port d'une lentille cornéenne (LC) souple asphérique, par rapport à une LC sphérique, chez des sujets myopes. **Méthode :** Des mesures de sécheresse oculaire et d'aberrométrie ont été effectuées sur un échantillon de 15 sujets myopes âgés de 20 à 30 ans. L'aberrométrie était mesurée dans trois conditions : 1. avec une LC sphérique, 2. asphérique ou 3. sans LC. Pour chacune de ces trois conditions, la racine des moindres carrés (RMC) des AOS, l'aberration sphérique (AS) et la coma ont été mesurées à cinq reprises dans un intervalle de 15 secondes durant lequel le sujet devait s'abstenir de cligner des yeux. **Résultats :** Les AOS augmentent lors du port d'une lentille sphérique. Avec les LC asphériques, l'augmentation des AOS tend à être plus faible. La LC sphérique provoque une augmentation significative de l'AS et de la coma horizontale par rapport à la condition sans LC. Pour la LC asphérique, on note une tendance vers une progression moins importante de ces aberrations, quoique les différences entre ces deux types de lentilles ne soient pas statistiquement significatives. Quant aux variations inter-clignement, il y a une augmentation semblable des AOS et des modes individuels dans le temps pour les trois situations. **Conclusion :** Il y a une tendance vers moins d'AS, de coma horizontale et d'AOS en général lors du port d'une LC asphérique par rapport au port d'une lentille sphérique. Par ailleurs, toutes les aberrations mesurées augmentent lors d'un intervalle prolongé entre les clignements, peu importe la condition testée.

Abstract

Purpose: To measure the level of higher order aberrations (HOA) when wearing a soft aspheric contact lens (CL), compared to a spherical CL, in myopic subjects. **Method:** Fifteen myopic subjects aged 20-30 years were tested for the presence of dry eye. Aberrometry measurements were done without a contact lens as well as with a spherical CL and an aspheric CL. Root mean square error (RMS) of HOA, spherical aberration (SA) and coma were measured five times in an interval of 15 seconds without blinking for each of the 3 conditions. **Results:** Wearing a spherical CL produced a significant increase of SA and horizontal coma compared to an eye without a contact lens. When wearing an aspheric CL, there was a trend towards a smaller increase of these aberrations. However, the difference between both types of lens was not statistically significant. In terms of total HOA, these were higher when wearing the spherical CL, while they tended to be less with the aspheric CL. As for the variations between blinks, there was a similar increase in total HOA and individual modes with time for the three

conditions. **Conclusion :** Wearers of aspheric CL seem to show a tendency towards smaller amounts of SA, horizontal coma and HOA in general in comparison with wearers of SCL. However, total HOA increases during a long interval between blinks, no matter the condition

MOTS CLÉS:

LC souple, LC asphérique, aberrations du front d'onde, aberrations sphériques, coma

INTRODUCTION

Depuis la fin des années 1990, un intérêt croissant s'est développé pour l'amélioration de la qualité optique de l'œil. Afin d'améliorer la performance visuelle, des compagnies de lentilles cornéennes (LC) ont développé des lentilles dites à « haute résolution » qui permettraient de corriger l'aberration sphérique (AS) en plus de corriger l'erreur de défocalisation (myopie et hypermétropie) et l'astigmatisme. Une diminution des aberrations permet une meilleure focalisation de l'image. Comme démontré dans le passé, l'AS inhérente au système optique de l'œil touche 90 % de la population et introduit, en moyenne, 0,15 μm d'aberration positive¹. L'AS est l'une des nombreuses formes d'aberration du front d'onde lumineux qui touchent l'œil humain. Il est également établi que pour un porteur de LC, la qualité de la vision est non seulement influencée par l'optique de l'œil, mais aussi par les propriétés optiques des lentilles correctrices ainsi que par leur interaction avec l'œil, surtout au niveau de la cornée et du film lacrymal². Ainsi, il sera pertinent d'étudier l'effet de ces LC asphériques sur différents types d'aberration.

Dans deux études récentes, on a démontré, par analyse du front d'onde, que certaines LC souples sphériques utilisées pour la correction de la myopie font augmenter l'ensemble des AOS en comparaison à une condition sans port de lentille^{2,3}. En 2003, Lu et al. ont également démontré que les porteurs de LC souples sphériques ont en moyenne plus d'AOS comparativement aux non-porteurs. Par contre, ils ont aussi noté une grande variabilité de ces changements d'aberrations entre les porteurs. Ces auteurs sont d'avis qu'étant donné les variations individuelles importantes, la correction des aberrations en LC devrait se faire de façon personnalisée⁴.

L'œil ne possède pas un système optique sans aberration et le front d'onde qui résulte du parcours de la lumière à travers les différents dioptries des médias oculaires subit des déformations. En optique, les déformations de la sphéricité du front d'onde lumineux atteignant la rétine sont qualifiées d'aberrations. Ces aberrations font que l'image produite par l'œil d'un objet ponctuel n'est plus un point, mais plutôt une tache de forme irrégulière. La méthode la plus répandue pour représenter les aberrations du front d'onde est le polynôme de Zernike. Selon ce modèle, les différents types d'aberrations sont représentés par des modes s'insérant à l'intérieur de différents ordres et sont quantifiés par le coefficient de ces modes. La somme de ces modes individuels forme le polynôme. Les ordres trois et plus sont qualifiés d'ordres supérieurs. Les plus notables de ces modes sont la coma verticale et horizontale, le trefoil et l'AS. Un des indicateurs les plus utilisés de l'aberration totale de l'œil est la racine des moindres carrés (RMC). La RMC se définit par la racine carrée de la somme des carrés des coefficients de Zernike. Une RMC de valeur élevée engendre une diminution de la qualité optique. Il est à noter que, de manière naturelle, les aberrations entre les deux yeux sont généralement sensiblement symétriques^{10,11}.

Le film lacrymal précornéen est important pour la protection de la surface oculaire, mais aussi pour assurer une surface optique de qualité⁵. Il représente la surface optique la plus puissante de tous les dioptries oculaires, en raison de l'importante différence d'indice de réfraction entre l'air et les larmes⁶. En conséquence, une légère variation de son épaisseur ou de sa régularité produira des aberrations importantes. Donc, le maintien d'un film lacrymal uniforme est essentiel pour procurer une image rétinienne de haute qualité^{6,7}. Montés-Micó et al. ont démontré qu'après le clignement, le film lacrymal se stabilise rapidement, ce qui produit une diminution des aberrations d'ordres supérieurs. Par la suite, celles-ci recommencent à augmenter suivant l'évaporation des larmes, ce qui mène à une irrégularité, puis au bris du film pré-cornéen⁸. Dans leur étude publiée en 2005, la quantité minimale d'aberrations a été mesurée à $6,1 \pm 0,5$ seconde après le clignement, en moyenne, chez des sujets normaux⁸.

Koh et al., ont démontré qu'il est possible de regrouper en quatre modèles différents les changements temporels dans les aberrations d'ordres supérieurs (AOS) totales se produisant après le clignement : le modèle stable, le modèle à petites fluctuations, le modèle en dents de scie et les autres modèles⁵.

D'autre part, une lentille asphérique comportant une correction pour l'AS risque, si elle est mal centrée, d'engendrer une quantité non négligeable de coma⁹. Sachant que les paupières se referment selon une progression latérale, en partant de la commissure externe vers l'intérieur, et connaissent l'influence de la gravité, et sachant que l'apex de la cornée est décentré en temporal chez la plupart des individus, on peut s'attendre à ce que la lentille ne soit pas parfaitement centrée et que sa position varie dans l'intervalle entre les clignements⁹.

Les AOS dégradent la qualité de l'image rétinienne. L'AS provoque un halo circulaire autour de l'image, tandis que la coma donne la forme d'une virgule à l'image d'un point. Cette dernière engendre donc une traînée floue à côté de l'image, parallèle à l'axe de symétrie de la « virgule ». L'influence de ces deux aberrations dépend fortement du diamètre de la pupille d'entrée du système optique. L'AS et la coma sont généralement les deux AOS les plus marquées dans l'œil humain.

La présente étude vise à mesurer le niveau des aberrations d'ordres supérieurs (AOS) lors du port d'une lentille cornéenne (LC) souple asphérique, par rapport à une LC sphérique, chez des sujets myopes, particulièrement dans l'intervalle entre les clignements.

La première hypothèse posée dans cette étude est que la situation avec la LC sphérique engendrera une augmentation des AOS chez une majeure partie des sujets. Ensuite, lors du port de LC asphérique, l'AS sera diminuée par rapport à la condition avec LC sphérique. Finalement, les AOS présentes entre les clignements varieront aussi selon la capacité de la lentille à maintenir la régularité du film lacrymal à sa surface, mais aussi selon la nature du design optique.

MATÉRIEL ET MÉTHODE

SUJETS

Quinze sujets âgés de 20 à 30 ans ont été recrutés pour tester les hypothèses. Les caractéristiques des sujets sont illustrées au tableau 1. Les sujets devaient être des porteurs de LC et présenter une myopie dont l'équivalent sphérique se situait entre -1,00 D et -7,50 D. L'astigmatisme ne devait pas dépasser le quart de la sphère. Les sujets ne présentaient pas de pathologie oculaire et n'avaient pas subi d'intervention chirurgicale ou de chirurgie réfractive pouvant avoir modifié l'intégrité de la cornée.

Pour ce qui est des lentilles, deux LC en ocuflcon D (gr. 1 de classification de la FDA) avec 55 % de teneur en eau ont été utilisées. Seul le design optique était différent : l'une était sphérique, l'autre asphérique.

Données démographiques de l'échantillon

Donnée	Âge	Myopie	Astigmatisme	K méridien plat	K méridien cambré	Diamètre pupillaire
Moyenne	22,9 ans	-3,48D	-0,2D	43,38D	44,00D	5,96mm
Écart Type	±1,44 an	±2,03D	±0,34D	±1,36D	±1,49D	±1,10mm

Tableau 1. Données démographiques pour les 15 sujets ayant complété l'étude.

INSTRUMENTS ET PROCÉDURES

Au cours de la première visite, chaque sujet a subi une évaluation pour confirmer qu'il remplissait les critères d'inclusion. Cette évaluation consistait en une réfraction subjective et une biomicroscopie des segments antérieur et postérieur de l'œil droit, puisque seul cet œil a été testé. La kératométrie et l'ajustement des LC ont également été vérifiés sur l'œil droit uniquement, au biomicroscope.

À la fin de cette visite, une évaluation quantitative du film lacrymal a été effectuée. Le volume des larmes a été mesuré à l'aide de fils de coton calibrés à cet effet (Zone-Quick™, Menicon, Japon). Ensuite, le temps de bris du film lacrymal (TBUT) a été évalué à l'aide de la fluorescéine et en observant l'œil du sujet avec un biomicroscope et un filtre jaune.

Au cours de la deuxième visite, les mesures d'aberrométrie avec le Nidek OPD-Scan II™ *optical path difference scanning system* (Nidek co., Japon) ont été effectuées. Cet instrument diagnostique est à la fois un autoréfractomètre, un topographe cornéen ainsi qu'un aberromètre. L'utilisation de cet appareil permet d'analyser quantitativement le front d'onde de la lumière réfléchi par la rétine, après son passage à travers les dioptries et médias oculaires. Ces mesures ont été effectuées sans dilatation pupillaire. Le NIDEK OPD-Scan II™ est constitué de deux systèmes principaux. Le système de projection consiste en une lumière infrarouge qui traverse une roue munie d'une fente produisant des faisceaux de lumière en direction d'une lentille et des miroirs. La roue tourne constamment à haute vitesse de façon à couvrir les 360° de la pupille. Les faisceaux de lumière pénètrent l'œil et sont ensuite réfléchis par la rétine pour se diriger hors de l'œil vers le système de réception. Finalement, ces rayons traversent une autre lentille, puis sont captés par un groupe de photo-détecteurs. La différence de temps que prend la lumière pour atteindre les photodétecteurs centraux et ceux en périphérie est convertie en puissance réfractive. Ce mouvement du centre vers la périphérie est analogue à celui d'un skiascope (rétinoscope) utilisé de manière standard en clinique pour mesurer objectivement l'erreur de réfraction oculaire. Les systèmes de projection et de réception tournent de façon synchronisée autour de l'axe optique de l'appareil afin de mesurer la réfraction de chaque méridien par compte d'un degré¹³. Dans les faits, cet instrument permet de faire l'acquisition de 1 440 points de données qui décrivent une carte de la réfraction à travers la pupille.¹⁴ Cette carte peut ensuite être convertie en carte d'erreur du front d'onde à travers la pupille. Cet appareil a été conçu pour une utilisation clinique.

La première étape était de qualifier la fiabilité de cet aberromètre. Cette validation a été effectuée sur un sous-groupe de cinq sujets, étant donné la limite de temps allouée à cette étude. Pour ce faire, trois mesures d'aberrations dans la condition sans LC ont été effectuées pendant deux journées.

Par la suite, pour chacun des sujets, les aberrations oculaires ont été mesurées dans la situation sans LC. Ensuite, les conditions avec lentilles sphériques et asphériques ont été évaluées tour à tour. La lentille était par la suite insérée dans l'œil au moins cinq minutes avant la prise de mesures. Ce délai permettait de stabiliser le film lacrymal et la lentille sur l'œil. À chaque prise de mesures par l'aberromètre, le candidat devait cligner trois fois, fixer une cible et garder les yeux ouverts jusqu'à la fin des mesures (intervalle de 15 secondes). La moitié du groupe a commencé avec la lentille sphérique et l'autre avec la lentille asphérique. Les mesures pour chacune des trois conditions ont été répétées à trois reprises. L'aberromètre a permis d'isoler les valeurs de RMC des différentes aberrations constituant le front d'onde. Les valeurs pour la coma verticale, la coma horizontale, l'AS et le total des aberrations d'ordre supérieur ont été extraites pour l'analyse.

Les données ont été analysées à l'aide du logiciel de statistiques SPSS™ 17.0 pour Windows™. Des modèles linéaires généraux ont été utilisés pour tester les différences significatives possibles dans les données recueillies en fonction des facteurs « type d'aberration », « type de correction » et « temps ». Lorsque c'était le cas, des comparaisons post-hoc entre les différentes conditions de port ont été effectuées à l'aide de tests paires sur les moyennes marginales estimées (avec ajustement de Bonferroni pour comparaisons multiples). Si le modèle linéaire général ne montrait pas de variation dans le temps, les moyennes marginales estimées n'étaient comparées qu'à la sixième seconde (moment où le film lacrymal est généralement le plus stable⁸). Dans le cas contraire, ces tests paires ont été faits chaque trois secondes de l'intervalle de 15 secondes pendant lequel le sujet ne devait pas cligner. Une valeur du coefficient de signification $p < 0,05$ était considérée comme significative.

Cette étude a été approuvée par le Comité d'éthique de la recherche des Sciences de la Santé (CERSS) de l'Université de Montréal et suit les normes éthiques en matière d'utilisation de

sujets humains en recherche (principes du protocole de Helsinki). Les participants ont été informés de la nature et des détails du projet et ont donné un consentement écrit avant leur participation.

RÉSULTATS

FIABILITÉ

Tout d'abord, l'aberromètre Nidek OPD-Scan II™ a procuré des mesures fidèles. Par exemple, pour quatre des cinq sujets testés lors des deux journées différentes, la différence des valeurs numériques obtenues pour l'AS entre les deux séances ne dépassait pas 0,05 µm. Ce qui n'est pas cliniquement significatif.

MESURES D'ABERRATIONS DANS L'INTERVALLE ENTRE LES CLIGNEMENTS

Par ailleurs, les moyennes et écarts types des aberrations étudiées pour les trois conditions de port sont rapportés dans les figures 1 à 3. Le diamètre pupillaire moyen lors des mesures était de 5,96 ± 1,10 mm.

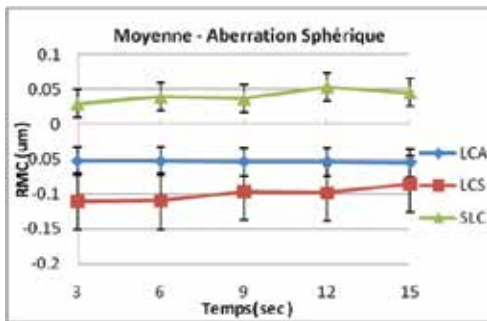


Figure 1. Évolution de la moyenne (n=15) de l'aberration sphérique durant l'intervalle de 15 secondes pendant lequel le patient devait garder les paupières ouvertes pour les conditions sans LC (triangle vert), avec LC sphérique (carré rouge) et LC asphérique (losange bleu). Les barres d'erreur correspondent à l'écart-type.

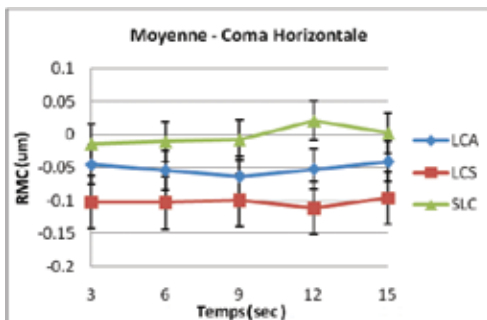


Figure 2. Évolution de la moyenne (n=15) de la coma horizontale durant l'intervalle de 15 secondes pendant lequel le patient devait garder les paupières ouvertes pour les conditions sans LC (triangle vert), avec LC sphérique (carré rouge) et LC asphérique (losange bleu). Les barres d'erreur correspondent à l'écart-type.

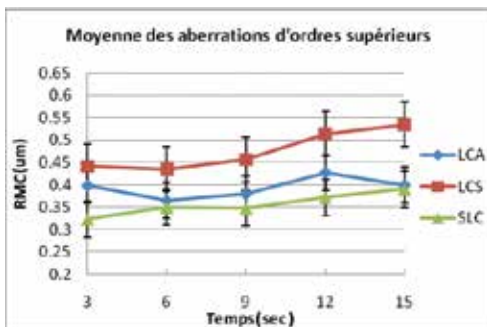


Figure 3. Évolution de la moyenne (n=15) du total des aberrations d'ordres supérieurs durant l'intervalle de 15 secondes pendant lequel le patient devait garder les paupières ouvertes pour les conditions sans LC (triangle vert), avec LC sphérique (carré rouge) et LC asphérique (losange bleu). Les barres d'erreur correspondent à l'écart-type.

a) Aberration sphérique

Pour ce qui est de l'AS, l'analyse du modèle linéaire général a révélé que cette aberration ne variait pas dans le temps pour les trois conditions durant l'intervalle de 15 secondes (p=0,491).

À la sixième seconde, les moyennes marginales estimées ont présenté une différence statistiquement significative (p<0,0005) entre la condition sans LC par rapport au port de la LC sphérique (p=0,008) ou de la LC asphérique (p=0,001) (figure 1). La moyenne de l'AS mesurée

chez les sujets sans LC était de +0,040 µm par rapport à -0,110 µm, à la suite de la pose de la LC sphérique. Cependant, la comparaison par paires des moyennes marginales estimées n'a pas démontré de différence significative entre les conditions de port d'une LC sphérique et asphérique (p=0,486). La lentille asphérique montrait tout de même une tendance à diminuer l'AS totale (œil + lentille) par rapport au port d'une LC sphérique. Par contre, la situation sans LC était néanmoins celle où la moyenne de l'AS était la moindre.

b) Coma

Aucun changement dans le temps pour chacune des trois conditions n'a été observé pour la coma horizontale (modèle linéaire général, p=0,649).

L'analyse des moyennes marginales estimées, à la sixième seconde, a démontré une différence significative entre le résultat obtenu sans LC et celui avec une LC sphérique (p=0,025) (figure 2). La LC sphérique tendait à produire une quantité plus élevée de coma horizontale comparativement à la LC asphérique. Cependant, la coma horizontale avec la lentille asphérique n'était pas significativement différente de celle de l'œil sans lentille (p=0,074).

Par ailleurs, un modèle linéaire général n'a révélé aucune différence statistiquement significative pour ce qui est de la coma verticale pour les trois conditions de port (p>0,05).

c) Relation entre l'aberration sphérique et la coma horizontale

Une analyse de corrélation de Pearson a démontré l'existence d'une association entre l'AS et la coma horizontale pour les situations sans LC et avec LC sphérique. Le tableau 2 fournit le coefficient de détermination (r²) observé dans ces conditions à chaque temps échantillonné. Pour la condition sans LC, toutes les corrélations dans ce tableau se sont avérées statistiquement significatives, sauf celle à la 12^e seconde de la situation sans LC. Cette dernière va tout de même dans le même sens que les autres valeurs. Toutes les corrélations avec LC sphérique se sont avérées statistiquement significatives. Par contre, aucune corrélation n'était significative en présence d'une LC asphérique.

d) Total des aberrations d'ordres supérieurs

Enfin, pour ce qui est de l'évolution dans le temps du total des AOS, un modèle linéaire général montre qu'il existait une variation significative (p=0,013) pour la moyenne des AOS totales pour les trois conditions. Les comparaisons par paires (moyennes marginales estimées) ont permis d'établir que le changement se produit entre la sixième et la quinzième seconde (p=0,008) ainsi qu'entre la neuvième et la quinzième seconde (p=0,007).

Le modèle linéaire général pour la quantité totale des AOS a démontré une différence significative entre les trois conditions de port (p=0,021) (figure 3). Cependant, les comparaisons par paires (moyennes marginales estimées) n'arrivaient pas à mettre de l'avant une différence significative entre deux conditions de port (p>0,05). Lors du port de la LC asphérique, la moyenne des AOS semblait se rapprocher de la condition sans LC, alors qu'il y avait davantage d'aberrations avec la LC sphérique.

Corrélation entre l'Aberration Sphérique et la Coma Horizontale (R ²)			
	Sans Lentille Cornéenne	Lentille Cornéenne Sphérique	Lentille Cornéenne Asphérique
3 ^e seconde	0,647**	0,694**	0,403
6 ^e seconde	0,586*	0,736**	0,424
9 ^e seconde	0,544*	0,772**	0,343
12 ^e seconde	0,454	0,770**	0,465
15 ^e seconde	0,519*	0,798**	0,476

*La corrélation est significative au niveau 0,05 (bilatéral)
 **La corrélation est significative au niveau 0,01 (bilatéral)

Tableau 2. Coefficients de corrélation de Pearson pour la relation entre l'aberration sphérique et la coma horizontale à chaque 3 secondes de l'intervalle de 15 secondes durant lequel le patient devait garder les paupières ouvertes pour les conditions sans LC et avec LC sphérique. Le tableau indique la force de cette relation dans les trois conditions testées.

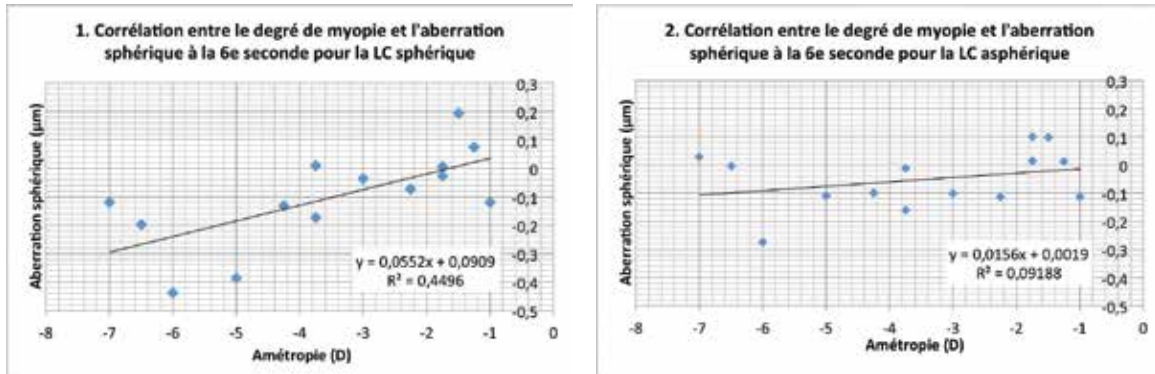


Figure 4. Relation entre l'amétropie des sujets ($n=15$) et l'aberration sphérique totale (œil plus LC) à la 6^e seconde de l'intervalle de 15 secondes durant lequel le patient devait garder les paupières ouvertes pour la LC sphérique (1) et la LC asphérique (2).

DISCUSSION

La moyenne de l'AS mesurée chez les sujets sans LC est de $+0,040 \mu\text{m}$ à la sixième seconde (moment où le film lacrymal est le plus stable⁸) (figure 1). Cette valeur se retrouve en deçà de l'AS moyenne retrouvée chez la majeure partie de la population, soit de $+0,15 \mu\text{m}$ d'AS positive¹. L'AS semble donc être moins positive chez les sujets majoritairement myopes qui ont participé à cette étude. À la suite de la pose d'une LC sphérique, la moyenne de l'AS est de $-0,110 \mu\text{m}$. Ce type de lentille introduit donc une quantité statistiquement significative d'AS négative dans l'échantillon étudié, ce qui concorde avec les prédictions de l'optique géométrique. D'après nos résultats (figure 4), il semble que plus la puissance d'une LC sphérique est négative, plus l'AS totale (œil + lentille) est négative (quoique la corrélation est moyenne avec un coefficient de détermination $R^2=0,4496$). Cette relation est très faible dans le cas de la LC asphérique avec $R^2=0,09188$ et non significative ($p>0,05$).

En fait, toute lentille divergente constituée de dioptries sphériques produit elle-même une AS négative. Par contre, si on considère seulement la tendance sur les moyennes, la LC asphérique produit moins d'AS négative ($-0,053 \mu\text{m}$) par rapport à la LC sphérique. Il est donc possible de supposer que les concepteurs de la LC asphérique ont donné une valeur négative ou neutre de correction d'AS pour les faibles puissances myopiques, sachant que l'AS de l'œil (positive) additionnée à celle induite par la nature concave de la LC demeurerait positive. Suivant les concepts de l'optique géométrique, il est probable que ces concepteurs de LC asphérique aient calculé la valeur négative de l'aberration sphérique de la lentille de contact qui corrige la myopie pour qu'elle soit complémentaire à l'aberration sphérique généralement positive pour ces yeux myopes. Quant aux LC asphériques de moyenne ou de forte puissance concave, la correction d'AS de la LC est en concordance avec l'AS négative de plus en plus grande produite par l'augmentation de la puissance concave de la lentille. Sans cette correction positive le montant d'AS produit par la lentille serait alors tellement élevé qu'il ferait basculer l'AS totale du couple œil-lentille vers le négatif. La lentille asphérique serait donc conçue de façon à induire une quantité d'AS nécessaire pour annuler la quantité produite habituellement par la puissance de la lentille elle-même¹⁵. C'est pourquoi l'inversion de signe de l'AS induite peut être observée chez les cinq participants portant une LC de puissance supérieure ou égale à $-5,00 \text{ D}$. De plus, il est possible d'observer dans la figure 1 que pour la moyenne des sujets, l'AS devient plus négative avec une LC sphérique. En portant une LC asphérique, cette aberration diminue en valeur absolue, mais sans rejoindre les valeurs obtenues sans LC. Cela confirme l'hypothèse de départ qui découle de la théorie que l'AS globale pourrait être mieux contrôlée avec une lentille asphérique. Toutefois, la présente étude ne confirme pas que la LC asphérique donne des résultats statistiquement significatifs. Il est à noter que les concepteurs des LC asphériques visent une valeur d'AS théorique. Dans les faits, il est possible que l'AS de l'œil de certains sujets soit différente de la valeur moyenne projetée. Donc, il est possible que pour ces sujets, l'AS soit pire ou ne s'améliore pas avec la LC asphérique à comparer avec celle mesurée avec une LC sphérique.

Les résultats pour la coma horizontale ont démontré une augmentation statistiquement significative pour la situation avec LC sphérique par rapport à sans LC (figure 2). Il semble y avoir deux facteurs principaux qui influencent la quantité de comas horizontales : la quantité d'AS induite par la LC et le décentrement. Comme indiqué plus haut, les puissances concaves élevées engendrent un transfert de l'AS vers les valeurs négatives lors du port d'une LC sphérique. Aussi, l'axe visuel est généralement décentré de $\frac{1}{4}$ à $\frac{1}{2}$ mm nasal par rapport à l'axe pupillaire (angle Kappa). Une LC aura tendance à se centrer sur l'apex cornéen, celui-ci étant habituellement temporal par rapport à l'axe visuel. Donc, lorsqu'un sujet regarde à travers une LC avec son axe visuel, il n'est pas exactement centré sur l'axe optique de la LC. L'AS de la LC couplée au décentrement de celle-ci par rapport au système optique de l'œil pourrait produire de la coma horizontale. Plus la puissance de la lentille sphérique est élevée, plus elle induit de l'AS et plus le décentrement induira un montant de coma horizontale important. Cette relation expliquerait la corrélation entre l'AS et la coma horizontale pour la situation avec LC sphérique (tableau 2). Cette même corrélation est retrouvée, mais à un niveau plus faible, lorsque les sujets ne portent pas de lentilles. D'après les résultats, la coma horizontale a tendance à être moindre avec le port d'une LC asphérique comparé à celle d'une LC sphérique. En fait, l'AS est moins élevée lors du port de la lentille asphérique qu'avec la lentille sphérique, donc moins de coma horizontale est produite par le décentrement dû à l'angle entre l'apex cornéen et l'axe visuel. En ne considérant que les valeurs numériques obtenues, la coma horizontale demeure à son minimum dans la situation sans LC.

Puisque l'axe visuel et l'apex sont décentrés sur un plan horizontal plutôt que vertical, la même tendance n'est pas observée lors de l'étude de la coma verticale. Aucune tendance significative pour cette aberration n'est donc observée.

Lors de l'analyse de la quantité de l'ensemble des AOS, aucune différence significative n'a été mise de l'avant à la suite de la comparaison par paires des trois conditions (figure 3). Il est tout de même possible d'observer une différence à la limite de la signification statistique ($p = 0,054$) entre la moyenne des AOS présente lors du port d'une LC sphérique par rapport à la condition sans LC. La LC sphérique induit une quantité plus élevée d'AOS durant tout l'intervalle entre deux clignements. Toutefois, aucun des deux modes de correction n'est préférable pour freiner l'augmentation de la quantité d'AOS plus le temps avance suite au clignement. Une augmentation significative des AOS a été démontrée pour toutes les conditions en comparant les résultats de la sixième et de la neuvième seconde avec ceux observés à la quinzième seconde. En accord avec le TBUT moyen des sujets (sept secondes après le clignement), cette augmentation pourrait être attribuable à un amincissement du film lacrymal à la suite de son bris. Cette quantité d'AOS induite contribue certainement à diminuer la qualité visuelle lors d'une tâche demandant une concentration. Bref, aucune des deux LC testées n'aident à contrôler les AOS à la suite du bris des larmes.

CONCLUSION

Dans cette étude, les deux types de lentilles (sphériques et asphériques) augmentaient la quantité d'AS, de coma horizontale et d'AOS totales chez les porteurs. Cependant, le port d'une LC asphérique tend à réduire la quantité de toutes les aberrations étudiées, comparé au port d'une lentille sphérique. La LC asphérique s'avère particulièrement bénéfique chez les myopes de plus de 5 D porteurs de LC sphériques, puisque ces dernières induisent une quantité importante d'AS négative et possiblement de la coma horizontale. L'AS et la coma ne variaient pas de manière significative entre les clignements. Cependant, le total des AOS augmentait de manière significative dans l'intervalle entre ceux-ci. Il pourrait être intéressant de reproduire cette étude avec une LC constituée d'un matériel qui s'assèche moins rapidement afin que l'AOS soit plus stable dans le temps. Dans une étude future, il pourrait également être intéressant de former deux groupes distincts, soit l'un avec les yeux secs et l'autre avec les yeux normaux, afin de mieux définir la relation entre la sécheresse oculaire et les aberrations du front d'onde.

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Bilateral Inferior Altitudinal Defects Secondary to Stroke: A Case Series

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Abstract

Strokes or cerebrovascular accidents are the third leading cause of death in Canada, comprising 6% of all deaths in the country.¹ The elderly and the very young (fetus or newborn infants) are at highest risk for having a stroke with an associated increased risk of death or lasting neurological disability.²

According to the National Stroke Association recovery guidelines, 10% of stroke survivors will recover almost completely, 25% will recover with minor impairments, 40% will survive with moderate to severe impairments that require specialized care, 10% will require care in a long-term care facility, and 15% will die shortly after the stroke. The National Stroke Association estimates that there are 7 million people in the United States that have survived a stroke and are living with impairments. The Heart and Stroke Foundation's 2013 Stroke Report has estimated that 315,000 Canadians are living with the effects of stroke. This case series serves as a reminder that, although rare, bilateral inferior altitudinal visual field defects can also occur as the result of a stroke, to highlight the difficulties of orientation and mobility that can result, and to offer potential rehabilitative strategies.

KEY WORDS:

stroke, cerebrovascular accident, ischemic perinatal stroke, visual field

Résumé

Les crises cardiaques ou accidents vasculaires cérébraux sont au 3^e rang des principales causes de mortalité au Canada et représentent 6 % de tous les décès au pays¹. Les aînés et les jeunes enfants (foetus ou nourrissons) sont les deux groupes qui présentent le plus grand risque d'une crise cardiaque pouvant mener au décès ou à des troubles neurologiques permanents².

Selon les lignes directrices en matière de rétablissement de la National Stroke Association, 10 % des survivants d'un AVC se rétablissent presque complètement, 25 % se rétablissent avec des déficiences légères, 40 % survivent avec des troubles des déficiences modérées à graves qui requièrent des soins spécialisés, 10 % ont besoin de soins dans un établissement de soins de longue durée et 15 % meurent peu de temps après la crise cardiaque. La National Stroke Association estime que 7 millions de personnes aux

États-Unis ont survécu à une crise cardiaque et vivent avec des déficiences. Le rapport de 2013 de la Fondation des maladies du cœur estime que 315 000 de Canadiennes et Canadiens vivent avec les séquelles d'une crise cardiaque. Cette série de cas nous rappelle que bien qu'elles soient rares, des pertes altitudinales bilatérales du champ visuel inférieur peuvent également survenir à la suite d'une crise cardiaque et met en évidence les difficultés d'orientation et de mobilité qui peuvent en résulter, puis offre des stratégies de réadaptation potentielles.

MOTS CLÉS:

crise cardiaque, accident vasculaire cérébral, AVC ischémique périnatal, champ visuel

INTRODUCTION

It is estimated that 50,000 strokes occur in Canada every year, approximately one stroke every 10 minutes.³ Strokes can occur at any age, but the incidence increases significantly over the age of 60 years.³ The incidence of strokes during the perinatal period is second to that of adult age groups. Ischemic perinatal stroke (IPS) is estimated to have an incidence of between 1 in 2300–5000 births^{4–6} and is 17 times more common in the perinatal period than in childhood or older.^{2,7} There are two forms of stroke, ischemic and hemorrhagic.¹ In adults, the ischemic type of stroke makes up 80% of strokes and involves the interruption of blood flow to the brain by a thrombus or embolus, in contrast to the other 20% of strokes that are hemorrhagic.¹ In children, the ischemic type can make up between 50–70% of perinatal strokes.^{8,9} In addition to hemiplegia, dysphasia, vertigo, ataxia, nystagmus, and cognitive impairment, a stroke can result in visual field loss, which can complicate rehabilitation efforts.

Visual field loss or visual impairment has been reported to occur in up to 70% of adult patients who have suffered from a stroke.^{10–14} Spontaneous visual field improvement in the first 3–6 months has been reported in up to 50% of patients, although after this period, recovery has been reported to be possible but occurs at a much slower rate.^{11,15} Recovery is dependent on the extent of damage, and its ability to be reversed relies on collateral circulation,¹⁵ although no correlation has been found between type of patient, stroke, field loss, and recovery outcome.^{10,11} Homonymous hemianopia, a loss of the same lateral half of the visual field in both eyes, is the most common and occurs in up to two-thirds of people with visual field loss.^{10–12} Other visual field defects that can occur include quadrantanopias, constricted visual fields, altitudinal defects, macular sparing hemianopia, and checkerboard defects.^{10,12–14} Damage to the occipital lobe has been associated most frequently (54%) with visual field loss secondary to stroke.^{10,11,15,16} The visual cortex is typically supplied by the calcarine artery, the terminal branch of the posterior cerebral artery (PCA).^{17,18} Supplementary branches to the visual cortex include the posterior temporal and parieto-occipital branches from the PCA and the occipital branches from the middle cerebral artery (MCA).^{17,18} The area of cortex representing the macula may be supplied by branches of the PCA, as well as the MCA. This allows for macular sparing when one of the two has been occluded.^{10,18–20}

PCA infarcts represent 5–10% of the documented strokes, and the leading symptom of PCA infarcts is visual (97%).²¹ Measurable visual field abnormalities are found in up to 93% of these patients, with the highest percentage having homonymous hemianopsia.²¹ Up to 8% are found to have bilateral visual defects, which are associated with multiple stroke events. Only up to 4% have a lower visual field deficit.²¹

Regardless of the type of stroke, it is necessary to determine the type of visual field defect in order to best help the patient develop coping strategies. Although bilateral inferior visual field defects may not be common, they cause significant difficulty with orientation and mobility, especially in unfamiliar environments. Two cases are presented with primarily inferior altitudinal visual field loss resulting from stroke in an elderly gentleman and in a young girl who had a perinatal stroke.

CASE REPORT 1

A 69-year-old man presented to the clinic on referral from a local hospital with a history of a cerebrovascular accident one month prior that resulted in visual perceptual changes. The preliminary in-hospital vision assessment revealed evidence of right-sided neglect and decreased visual tracking ability. His initial computerized axial tomography (CT) scan revealed bilateral cerebellar and occipital lobe hypodensity and hyperdensity of the ventricles. These findings were interpreted to represent posterior cerebral infarcts. An magnetic resonance imaging (MRI) was performed a few days later that suggested embolic stroke (bilateral cerebellar and occipital lobe) and possible posterior leukoencephalopathy. He was transferred to a facility for rehabilitation.

At the initial oculovisual assessment, he described that his central vision was clear but his peripheral vision was blurred. This represented an improvement over the total loss of vision that was experienced at the time of the stroke. The best-corrected visual acuity was 6/12-3 in the right eye and 6/6- in the left eye, with a refraction of OD: -3.00 -2.00 x 107 and OS: +1.25 -1.25 x 099. Eye movements were unrestricted, but pursuits were not smooth. Intraocular pressures were 15 mmHg in the right and 13 mmHg in the left eye. A dilated fundus exam revealed visually significant grade 1+ nuclear sclerosis, grade 2+ posterior subcapsular cataract and lens vacuoles in the right eye and grade 1+ nuclear sclerosis and lens vacuoles in the left eye. Pupils were round and reactive to light with no relative afferent pupillary defect. The posterior pole and peripheral examination were unremarkable. The optic nerves had cup-to-disc ratios of 0.5 horizontal/vertical (H/V) in the right eye and 0.45 H/V in the left eye. There was no evidence of any optic nerve pallor or hemorrhages and no nerve fibre layer defects. A Humphrey full field 120 degree visual field (Figures 1 and 2) was done and bilateral inferior altitudinal defects were detected, along with a diffuse superior defect and a tendency towards a right superior quadrantanopia in both eyes. The broad general loss detected on the visual field was attributed to cataracts, fatigue, and unfamiliarity with the test. A referral for a cataract surgery consultation and a repeat visual field were arranged.

Two weeks following the initial oculovisual assessment, the rehabilitation centre referred the patient back to our clinic because they were ready to discharge him from inpatient care, but he was still struggling with vision problems. He was continuing to have difficulty with peripheral vision and inferior visual field. Their concern was with navigating unfamiliar environments and their view was that he was unsafe to return home alone. Aided visual acuities were 6/15- in the right eye, 6/6- in the left eye, and 6/6-3 with both eyes together. The Humphrey full field 120 degree visual field was repeated with good reliability, revealing bilateral inferior altitudinal defects, less complete in the right eye, and the superior fields had more diffuse loss in both eyes (Figures 3 and 4). He was advised to actively tilt his chin to scan his inferior field, especially while walking, to help him navigate with more confidence. A referral for orientation and mobility training was suggested.

At one-month follow up post-cataract surgery, his unaided visual acuity in the right eye was 6/7.5, as reported by the ophthalmologist. Five months later he was living in a retirement home and satisfied with actively looking in his inferior field to help with orientation and mobility. He did not want further mobility training or visual field testing.

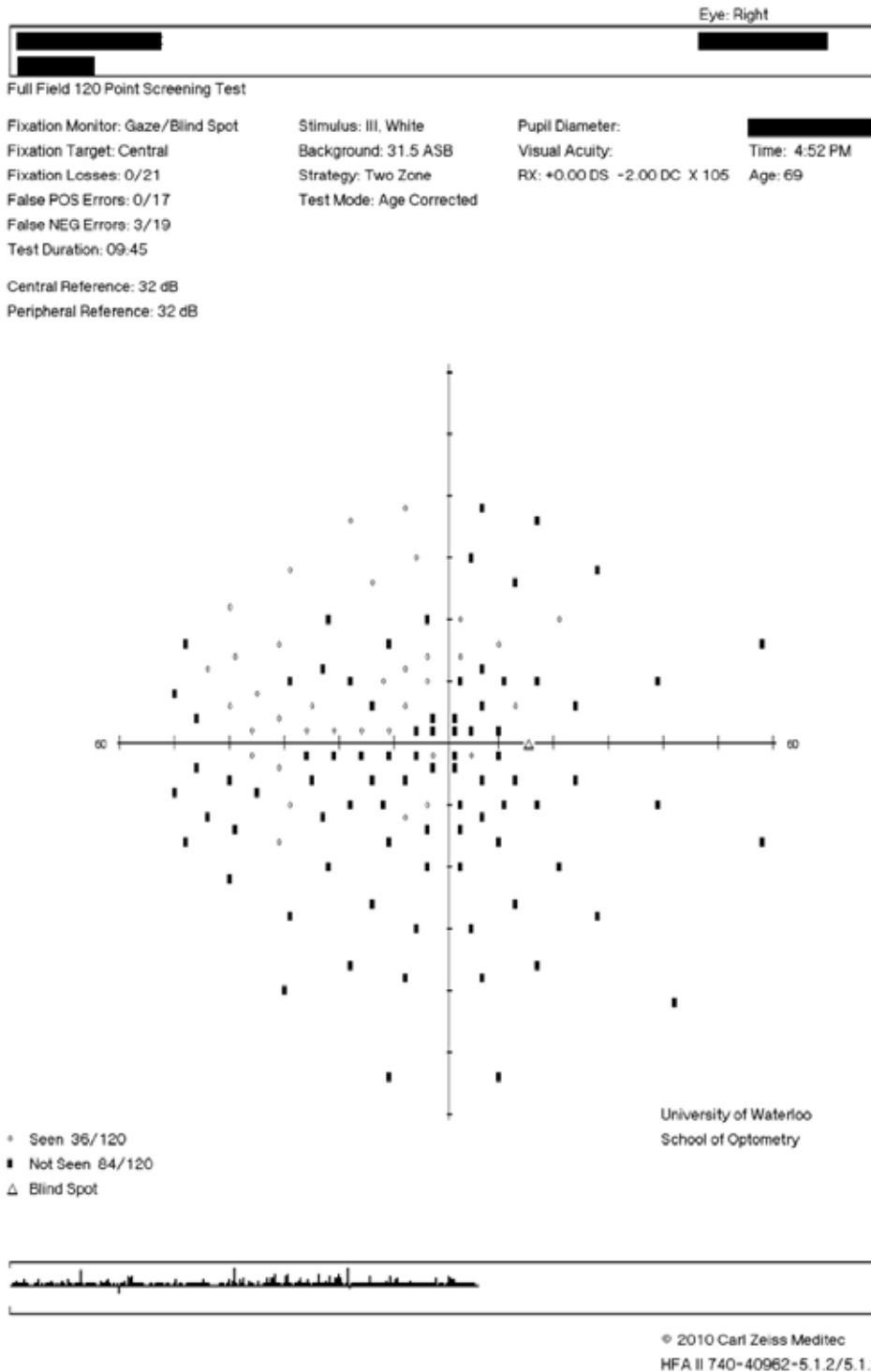


Figure 1. Initial visual field: right eye.

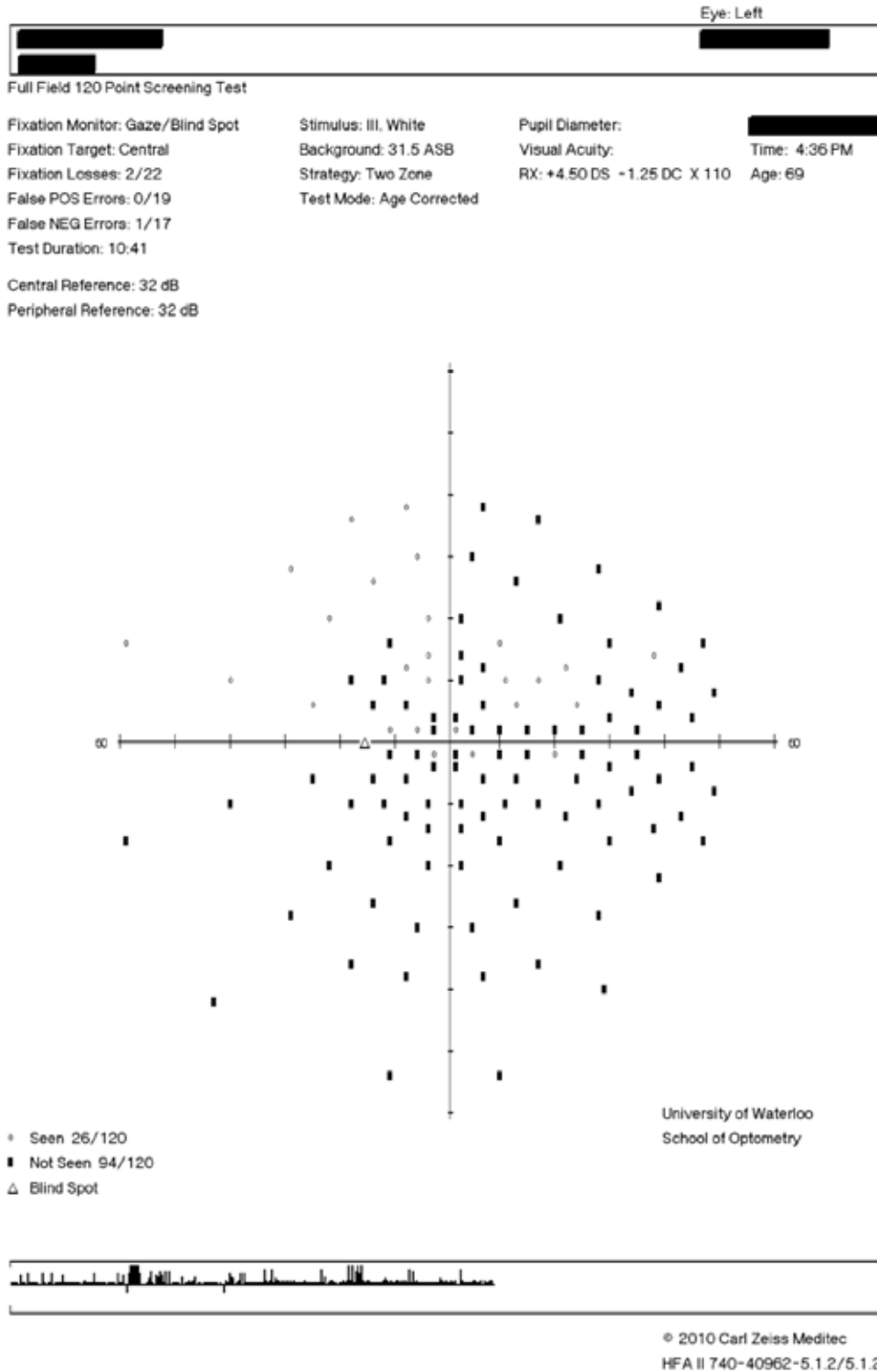


Figure 2. : Initial visual field: left eye.

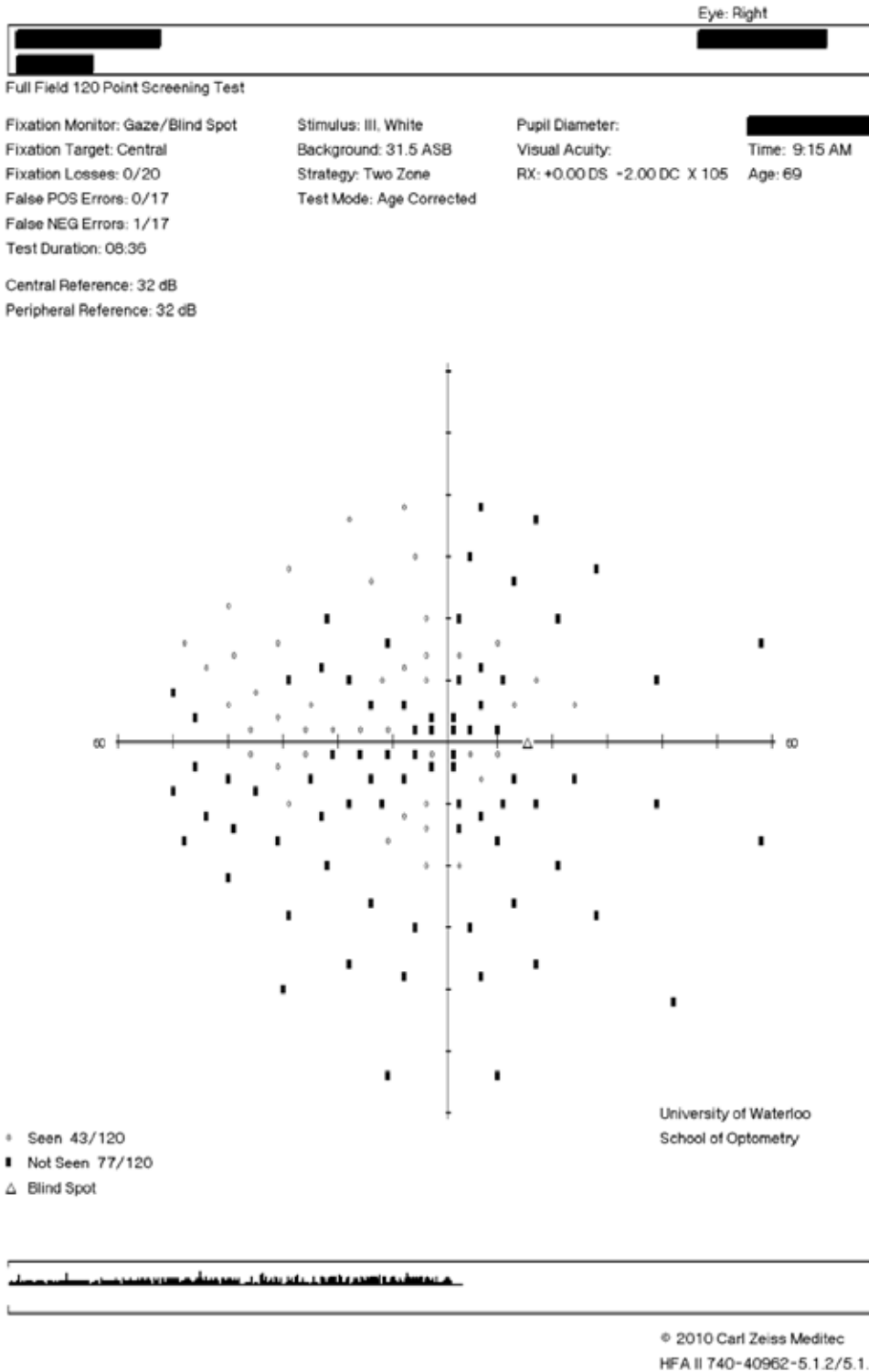


Figure 3. : Visual field of the right eye at follow-up.

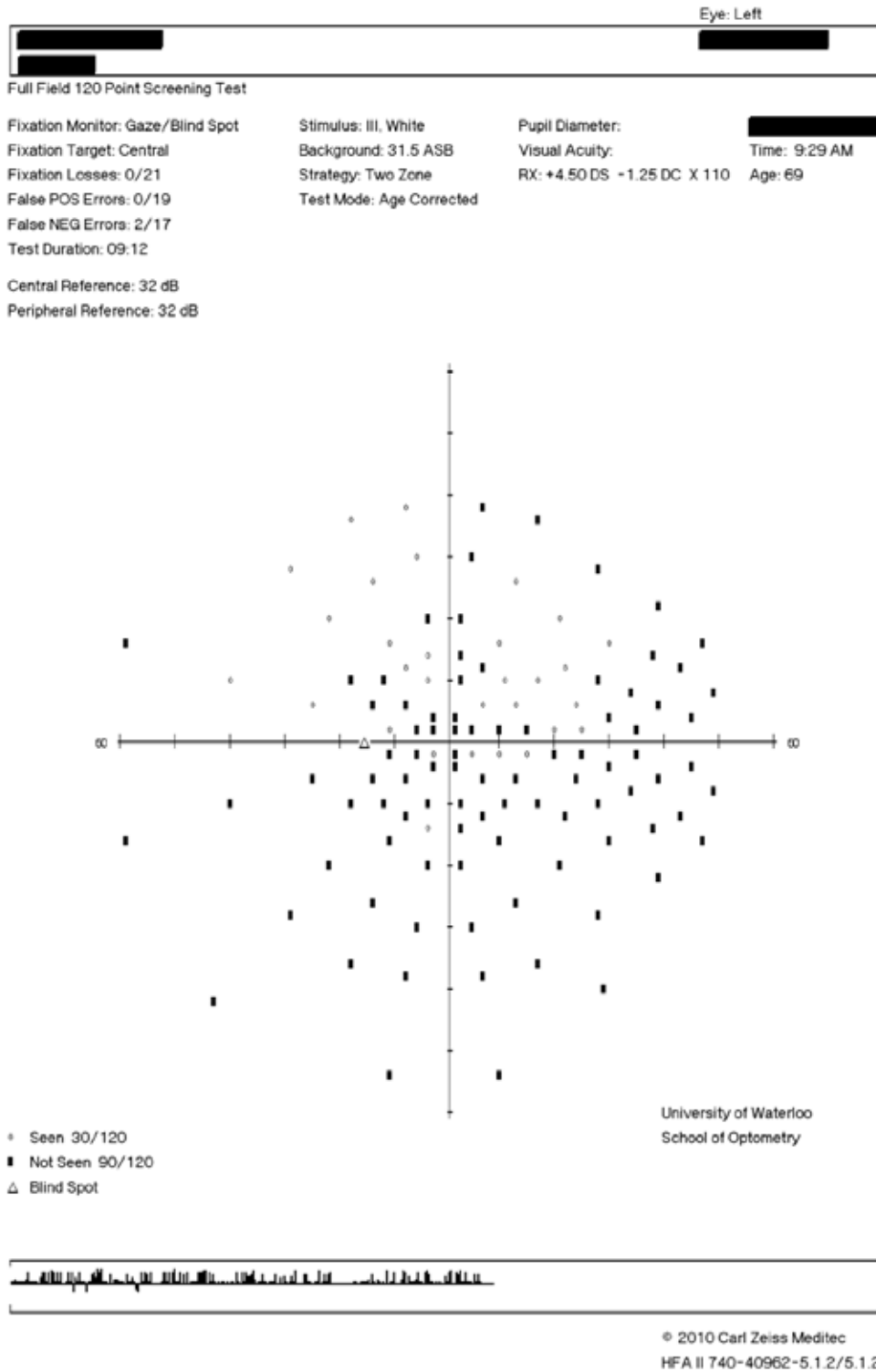


Figure 4. : Visual field of the left eye.

CASE REPORT 2

A 14-year-old girl presented for an assessment in the low vision clinic. She was born at full term, but during labour there was a drop in fetal heart rate, meconium in the amniotic fluid, and the chord was wrapped around her neck. Despite these issues there were no ocular or general health concerns at the time. Magnetic resonance angiography was performed at age three years due to concerns regarding developmental delay and strabismus (an alternating exotropia with inferior oblique overreaction). The results suggested hypoglycemia as the cause of the brain damage with encephalomalacia and damage to the frontal and occipital lobe. It was believed she suffered a stroke around the time of birth. Strabismus surgery was performed bilaterally at the age of four years that resulted in an esotropic overcorrection. Patching for amblyopia was done. It was noted that she was ignoring objects or light presented in her right field. At the age of five years, an assessment by an occupational therapy centre was completed. She was found to have low fine motor skills, inability to use both hands equally (right hand function was reduced), low visual attention and processing speed, weak graphomotor skills, and lower than average intellectual functioning. However, her expressive language functioning was in the 91st percentile, which included comprehension and effective use of language.

Her first assessment in the clinic was at the age of six years. A previous functional vision assessment performed by a vision itinerant teacher indicated that she had difficulty tracking, often lost her spot while reading, tripped over obstacles in the classroom (chairs, students), and was very cautious around stairs and curbs as a result of her constricted visual fields. Unaided visual acuities were 6/21 and 6/30. Motility testing revealed a slight restriction as well as nystagmus on left gaze. She had a 45 prism dioptre (pd) constant alternating esotropia at near becoming greater than 50 pd at distance, as well as a constant left hypertropia at distance and near latent nystagmus noted in the left eye. Fundus evaluation revealed optic nerve heads with symmetric healthy pink rim tissue in both eyes with cup-to-disc ratios of 0.2 in each eye. A low vision assessment was conducted to address school concerns, playing team sports (soccer), and navigating unfamiliar places. Goldmann visual fields revealed bilateral inferior visual field loss. Field expanding prisms were discussed for the future, as well as reverse telescopes (2.75X). High add readers (+4.00 D) were appreciated to help decrease strain and fatigue associated with prolonged near activities. A 1.7x dome magnifier allowed greater comfort with reading the finer print in a book that she had brought to the assessment. At age nine, she began treatment with a physician in Boston who had an interest in neurology and neural plasticity. She was using a computer-based program to improve her visual defects (13 sessions with improvement noted by neurologist).

At the most recent visit, the patient reported that her vision had been stable for a number of years. Despite demonstrating vast improvements in her independence at school, mobility was still a concern, although she reported that 90% of the time she felt comfortable with new surroundings. Aided visual acuities were OD 6/19+2 (-7.50 -2.50 x 180), OS 6/38+1 (-7.00 -2.50 x 180), OU 6/15-1. Goldmann visual fields were improved, although it was difficult to determine if there was true visual field improvement or better test performance due to increased age (Figures 5–8). Her vision was considered stable and she was doing well in school, was able to navigate her environment most of the time, and was continuing with the computer training. An appointment was offered to review field enhancement options.

DISCUSSION

The first patient suffered a bilateral posterior cerebral infarct that resulted in bilateral inferior field loss with macular sparing. To produce this type of field loss, the infarctions might have occurred in the calcarine terminal branches of the posterior cerebral arteries, above the calcarine fissure. The macular sparing was likely due to the dual supply of the macula by the middle cerebral arteries. For the second patient the MRI indicated bilateral occipital lobe damage along with smaller caliber middle cerebral arteries, which confirm the cause of her bilateral visual field defects with macular involvement. There was no indication of damage to her posterior cerebral arteries, but this would most likely be the cause of the inferior altitudinal defects. For both patients, pre-chiasmal or optic nerve head diseases were ruled out due to the healthy

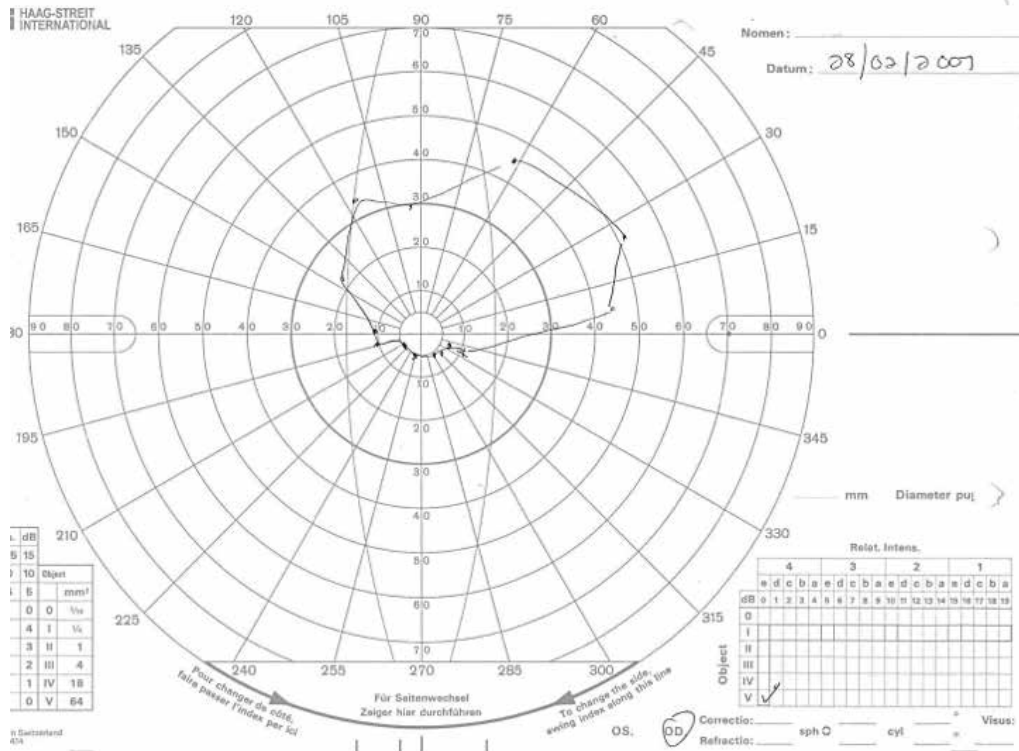


Figure 5.: Visual fields for AS at age 7 years, right eye.

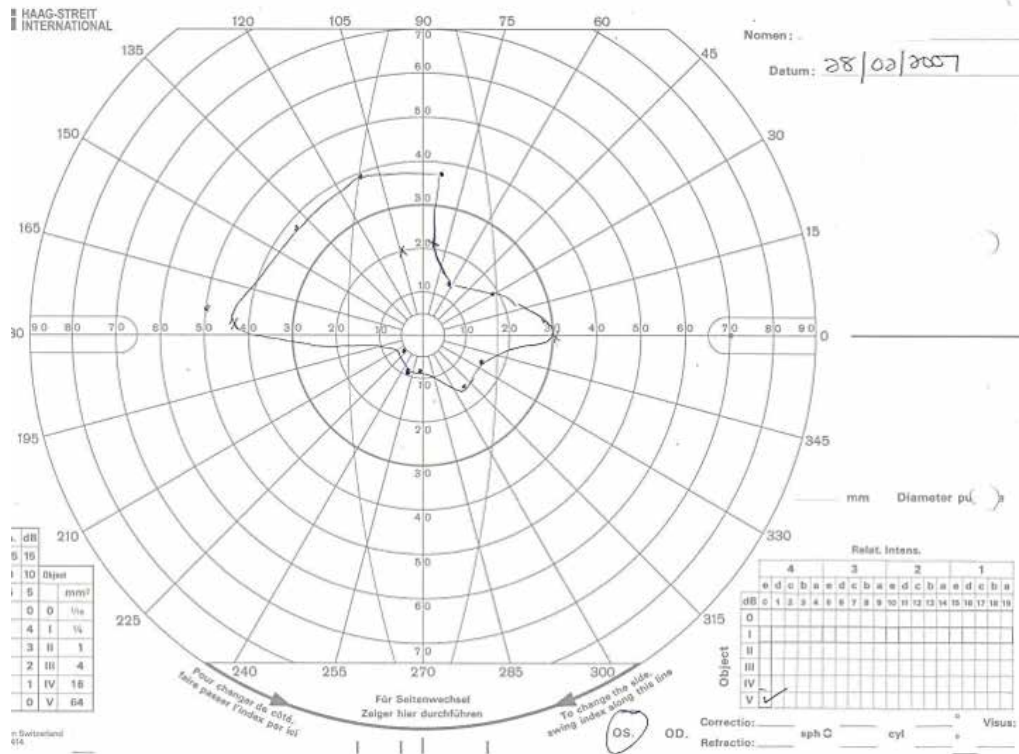


Figure 6.: Visual fields for AS at age 7 years, left eye.

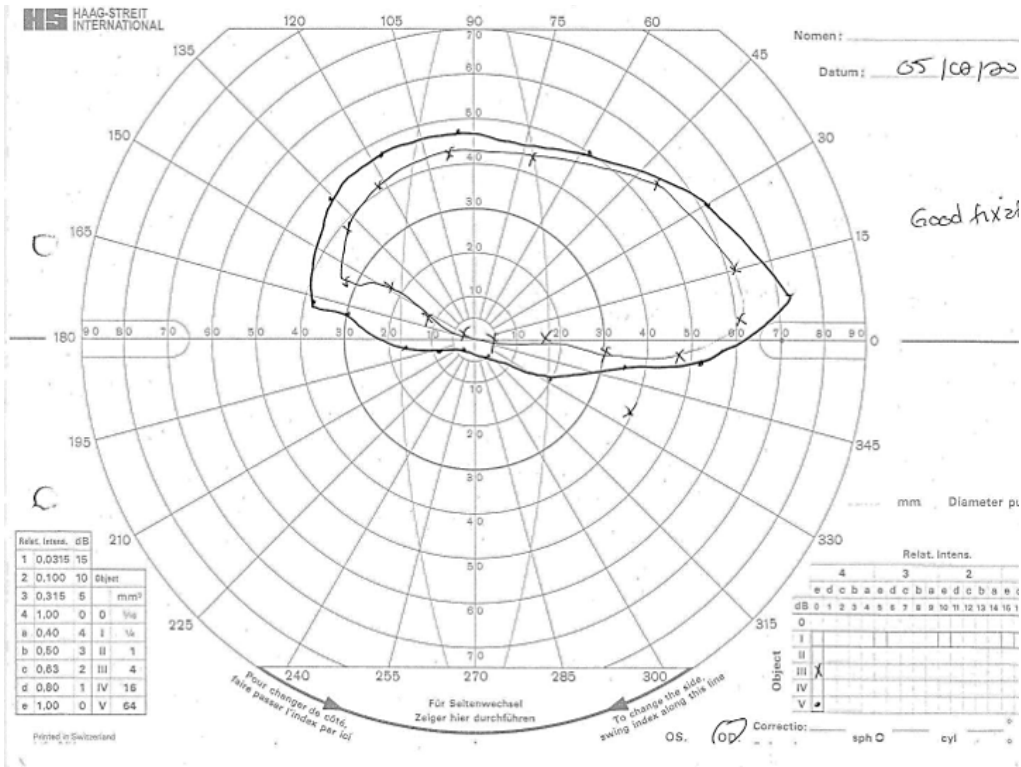


Figure 7 : Visual fields for AS at age 14 years, right eye.

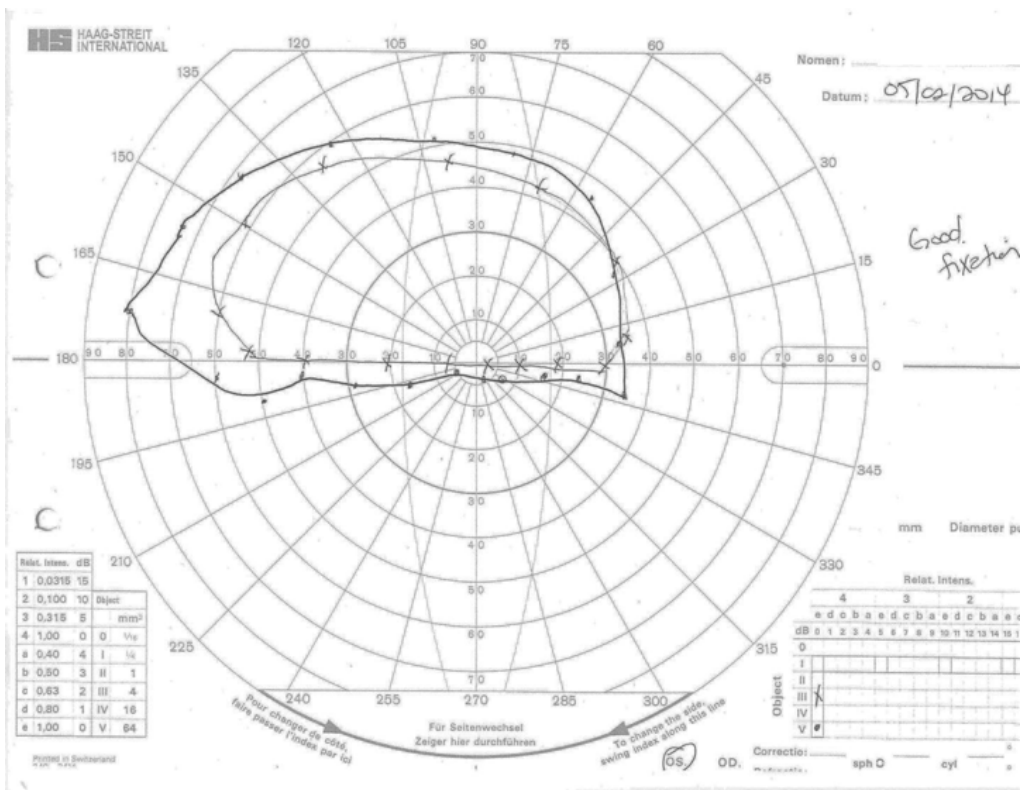


Figure 8 : Visual fields for AS at age 14 years, left eye.

appearance of the optic nerves and the absence of a relative afferent pupillary defect, although other supporting evidence that would be helpful for future diagnoses would include an optical coherence tomography scan and a Humphrey visual field including the mean deviation value.

Binocular inferior altitudinal visual field defects can be very debilitating, negatively impacting mobility, navigation, scanning, reading, and driving. Not only do visual field defects cause difficulty in activities of daily living, but they can also hinder a person's ability to seek help or participate in rehabilitation, decrease quality of life, and potentially cause depression and isolation. Detecting the full extent of a visual field defect in a young child may be difficult due to decreased attention, but attempts should be made to help facilitate rehabilitation. Automated perimetry is difficult in young children, although they can perform well with Goldmann perimetry, which is a form of kinetic perimetry. Goldmann perimetry permits the child to take frequent breaks. The perimetrist is able to modify the target size and number of points mapped, as well as monitor fixation directly during testing.

Plastic reorganization of the cortex after injury has been thought to be faster in children, which is demonstrated by the low incidence of abnormal vision after suffering from cortical damage.^{22,23} During the first few weeks of insult, it has been shown that there is a slight enlargement of the defective visual field that is a result of resolving tissue adjacent to the affected area or changes in the neural circuitry.^{24,25,18} With early brain damage, it is difficult to determine the extent of the vision loss, which is due to the low reliability of behavioural responses typically governed by attention.^{23,26} Knowledge of brain plasticity is currently limited and supported with non-human models, including the possibility of the development of new connections to by-pass damaged tissue and differentiation of functional tissue to compensate.²³

It has long been thought that structural changes in the primary visual cortex can only occur during the critical period of development (up to age 8 years).^{27,28} It has now been demonstrated that the cortical maps of adults are not fixed and can reorganize, resulting in changes in cortical topography.²⁹ Cortical plasticity allows for the ability to fill in images when there is a visual field defect and to spatially distort the field around scotomas to alter what is perceived.²⁹ There is no restoration of function of the destroyed tissue but compensation can occur in areas that are missing in our perception. This process of filling in causes a difference in the perceived defect, compared to the actual defect. The mechanisms that allow for cortical reshaping are thought to include changing the efficacy of pre-existing synapses, such as long-range horizontal connections, as well as creating new connections.³⁰⁻³² The expansion of the visual cortex is thought to be accomplished through bypassing the striate cortex to connect to areas such as the subcortical nuclei,²³ and it has been shown that the superior colliculus may be a key player in building connections for maintaining residual function as shown with functional MRI (fMRI).^{33,34} New areas of interest include the potential for implantation of stem cells or the use of progenitor cells for future rehabilitation.³⁵

Field enhancement and rehabilitation options can be considered if a homonymous hemianopic, inferior altitudinal, or overall constricted visual field defect remains following a stroke. Rehabilitation efforts endeavour to maximize the utility of the remaining vision and thereby lessen the associated impairment in function by using optical devices and/or visual training.

Optical devices used for rehabilitation include prisms to expand or relocate (enhance) the visual field and minification tools such as reverse telescopes. Prisms can be ground in or self-adhesive (Fresnel) and are effective for lateral hemifield loss. Ground-in prisms are optically clear but can be very thick, as the required prism magnitude for rehabilitation is rather large (20–40pd). Fresnel prisms are lighter; however, resolution and contrast sensitivity are reduced when viewing through the prism. A rigid Fresnel prism is another option that allows for the same permanency of a ground-in prism while retaining the other features. As the magnitude of the prism power required for field enhancement increases, the visual acuity and contrast sensitivity is compromised, as there are increased optical aberrations. Taken into conjunction with image shifting when the prism is engaged, it can be detrimental to mobility when applied inferiorly.

Traditionally, binocular sector prisms have been used for rehabilitation of field loss. They are placed on the spectacle lens over the affected half of the vision with the base oriented toward the hemianopic side, shifting images to the remaining field of functioning vision only when the individual looks through the prism^{36,37}; this creates an apical scotoma.³⁸ Alternatively, field expansion can be created with a monocular sector prism. It is placed over the half of the lens on the hemianopic side, with the same prism orientation as the binocular sector prisms. When the individual engages the prism, field expansion does occur, in conjunction with diplopia and visual confusion.³⁶ As the field defect demonstrated by the patients in this case report is located inferiorly, these common uses of prisms applied to glasses may not work as effectively as the resulting shift in perception or double vision, and visual confusion may act to further impair mobility and increase the risk of falls.

Peripheral prisms, also known as Peli prisms, are high-powered Fresnel prism segments (each 40 prism diopters) that are fit to the upper and lower portions of the lens on the hemianopic side, with the base of the prism in the direction of the field loss.³⁹ This use of prisms allows for double vision to only occur in the periphery and has been shown to expand the visual field by 22 degrees in both the upper and lower quadrants.³⁹ As the prisms extend on either side of fixation, the shifted image is always present, allowing for field expansion in all lateral gazes, as opposed to only direct gaze through the prism.³⁸

Subjectively, participants have rated the prisms helpful, particularly with obstacle avoidance and mobility.⁴⁰ Peli prisms are commonly used for temporal and nasal hemianopia. More recently, the oblique peripheral Peli prism design has been recommended, which allows for pericentral expansion of field. The 30-degree apex-base angle allows for responsiveness closer to the meridian while preserving single vision and circumventing central confusion and apical scotomas (with binocular viewing) when the prism is fit unilaterally. Peripheral visual confusion remains. When fit bilaterally, the peripheral confusion is minimized, but the apical scotoma is larger and there is some pericentral diplopia.³⁸ To our knowledge, there are no studies to date applying the Peli prism vertically for altitudinal defects. Monocular use of the Peli prism aligned vertically may provide some help but should be used with caution and may not be easy or intuitive to use.

Reverse telescopes can be used to minify the world to allow for a larger field of view to better identify obstacles and can also be used for any type of field loss. They may be handheld or spectacle-mounted in a bioptic position. They are typically used as a spotting tool in an unfamiliar environment in order to quickly locate obstacles. Minification results in a decrease in visual acuity and is tolerated well only by those individuals with good central acuity.⁴¹

Visual training techniques, such as modifications in visual behaviour, including increasing saccadic patterns and saccadic amplitudes into the blind field, have been a common method of compensating for visual field loss.⁴² These are incorporated into training programs to develop visual search strategies and for orientation and mobility. Training techniques include having patients perform exercises where they are directed to make repeated movements into the blind area in either a stepwise staircase method or in a manner that overshoots the target to bring it into the visual field. Saccades can also be trained with exercises to increase the size of the saccadic pattern, and this can be adopted into search pattern strategies. This is an intuitive training method to help patients with any type of field loss, including inferior field loss.

Computer training is another form of visual training rehabilitation that has been used to restore function and vision. Visual field restitution is a computer-based program using flicker to stimulate the border zone of the blind field to produce a reactivation in the cortical function of surviving neurons. It was developed based on the theory of neuroplasticity; however, the effectiveness of the treatment is debatable, as improvements in visual field have only been measured with the program and have not been repeated with perimetric testing.⁴³

The above strategies are designed to shift or increase the extent of the visual field; however, there is not enough evidence regarding benefits or the ability to improve daily living tasks.^{44,45}

At the moment it seems that training a person's ability to scan is the most promising method of treatment for inferior altitudinal defects, but more research is needed to confirm this.⁴⁵ Visual search strategies in conjunction with orientation and mobility training can help a patient to determine where they are in the space and to strategize how to get to where they want to go; they should be recommended to people with inferior field loss. This typically includes developing better sensory awareness, understanding relationships between objects, developing searching skills, and using aids like a walking stick, a guide, or a guide dog. Optical devices, including prisms for rehabilitation of inferior field defects, should be used with caution and with ample training on use.

Children with congenital visual field defects or defects that occurred at a young age, including those secondary to stroke, have the potential to adapt and overcome these deficits. If the defects are identified at an early age, modifications can be created to help with learning and ensuring a safe environment. Similar strategies for rehabilitation could be used for acquired and congenital forms of visual field loss, including mindfully placing objects in the field of good vision, optical enhancement, and computer training programs. However, patients with congenital field loss may not report as much improvement with various forms of rehabilitation if they have already developed their own strategy for compensation.

Further research is needed to develop rehabilitation strategies that will aid patients with inferior altitudinal visual field loss with their activities of daily living, to allow for safe reintegration into society.

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Negotiating the Rental Rate for Optometry Tenants

By: Jeff Grandfield and Dale Willerton – The Lease Coach



Dale Willerton is the founder of The Lease Coach and Jeff Grandfield recently joined him as partner. Dale and Jeff are commercial lease consultants who work exclusively for tenants, and are also professional speakers and co-authors of Negotiating Commercial Leases and Renewals For Dummies. Got a leasing question? Need help with your new lease or renewal? Call 1-800-738-9202, email DaleWillerton@TheLeaseCoach.com, or visit www.TheLeaseCoach.com. For a copy of our free CD, Leasing Dos & Don'ts for Commercial Tenants, please email your request to DaleWillerton@TheLeaseCoach.com.

Every optometry tenant wants to pay the least amount of base rent possible. Every landlord wants to get more rent. In negotiating your rent (either initially or when negotiating your lease renewal), it's important to realize that not all tenants pay the same rent per square foot – that amount is negotiable based on many factors. It's equally important to understand that the landlord's asking rental rate is what they need to satisfy their financial commitments or what they hope to achieve in the marketplace and not necessarily what you can afford to pay in rent.

It should come as no surprise that rent is one of your major business expenses. Your rental rate is also a major factor if and when you sell your clinic. If a prospective buyer believes that your rent is too high, you may be unable to sell as the buyer is essentially scared off by the overhead.

Never underestimate the importance of the right rental price. Rent can make or break your clinic. If you're struggling to pay your rental rate, there are two possibilities: either your rent is too high or your patient count is too low.

If your landlord is smart, he doesn't just pull a rental figure from the air. A typical commercial developer sets rental rates based on a simple formula whereby the rental revenue from the tenants covers the mortgage and provides the landlord with a 7 - 15% percent *capitalization rate* (or return on investment).

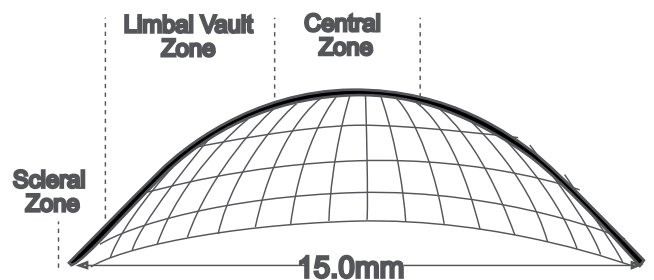
Mathematically, this is an easy calculation for the landlord – it involves two numbers or factors: the face rate versus the net effective rental rate. The face rate is the dollar amount you pay and the amount that appears on the lease agreement. The net effective rental rate is the amount left for the landlord after deductions for real estate commission, inducements and incentive packages, the landlord's work done to the commercial space, and so on. With a \$24.00 per square foot rental face rate, the net effective rent the landlord is left with can easily be reduced to \$17.00 per square foot after these deductions.

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While knowing what other businesses in the same building you lease space in is a good idea, expecting their rent per square foot to be the same as yours isn't always realistic. There are legitimate reasons why various tenants pay differing rental rates in the same property:

Size: With commercial rent charged by the square foot, tenants leasing larger areas may pay less rent per square foot than you. Conversely, tenants leasing a smaller unit may be paying a premium for the smaller space.

Term: The number of years the tenant has agreed to lease can also be a factor. A longer lease term doesn't necessarily mean a lower rental rate; it will depend on the current economy and occupancy of the property, at the time the lease was signed.

Inducements: The dollar value of the inducement package impacts the tenant's rental rate. Although most landlords build some financial inducements into their asking rental rate, the two are connected.

Timing: The timing of when a business becomes a property tenant matters. In a newly-developed property, the first and last tenant in may pay different rates.

Most commercial leases are *triple net* leases; this means that all costs related to the property are passed through to the tenants. These operating costs (also known as Common Area Maintenance / CAM charges) and property tax charges are typically stated as a separate or additional rent, which the tenant must pay. In some cases, the operating costs are equivalent to or even more than a tenant's base rent.

The base or minimum rental rates stated per square foot probably don't include any charges the landlord wants for signage, storage, parking, utilities, and so on. Other costs indirectly related to the lease can be property taxes, business taxes, and insurance. It's extremely important to have absolute clarity on what rents and related costs you have to pay.

A general rent range figure is that tenants should budget to pay between 5 – 12 percent of their gross sales in rent. The higher your patient volume, the more important every percent becomes to your bottom line.

One doctor came to us and wanted help with a new lease. He had found a jewel of a location; however the rental rates per square foot were so high that we had to talk him out of the location because he would have been paying more rent than our other medical/healthcare clients. It simply wasn't realistic for him to expect to be able to pay a higher rental rate.

Landlords anticipate that the cost of living or Consumer Price Index (CPI) may increase over time, and it usually does. This is called *inflation* by its simplest definition. Therefore, the landlord wants to build *steps*, or annual increases, into a tenant's five or 10-year lease term. This may be stated as a rent per square foot, such as \$25.00 per square foot the first year with a \$1.00 per square foot increase each year thereafter. Many lease agreements state that the annual rent increase may be calculated as a percentile factor, such as 3, 4, or 5 percent. Fight like crazy on these annual base rent CPI and percentage increases. Every percentage point counts. In some parts of the country, landlords are satisfied to receive a flat rent for a full 5-year lease term. It's all negotiable.

Considering the average optometrist tenant stays in the same location for at least ten years, it's easy to calculate the total rent that you may pay to the landlord over that time period. This is often more than you've paid for a house! For this reason, you need to develop a grave respect for rent. On a monthly basis, it may not seem like such a big expense, but most optometrist tenants aren't leasing space on a monthly basis, but instead for a much longer term. The economy can crash and rebound in one entire lease term ... what you need is a long-term vision.

While you are negotiating or renegotiating your rental rate, don't forget to include your operating costs as your secondary rent. Although most commercial real estate professionals may tell you that operating costs are not negotiable, there are aspects of these that can be changed to the tenant's favor. The landlord wants to make sure that the tenants pay for all the operating costs for the property. There's nothing unusual about that. But when we analyze operating costs for groups of tenants in a building, we frequently find that the tenants are subsidizing capital improvements that the landlord is using to increase the building's value.

When it comes to operating costs, look at what you're paying for. The majority of commercial and office lease agreements may stipulate the specific components of the operating costs that tenants need to pay for. Typical examples of valid operating costs include general maintenance, painting, lawn cutting, snow removal, and property insurance. Almost every lease agreement has an operating cost clause which typically defines these common area maintenance charges in either a short- or long-form manner. From a tenant's perspective, a longer description is better as it creates more certainty.

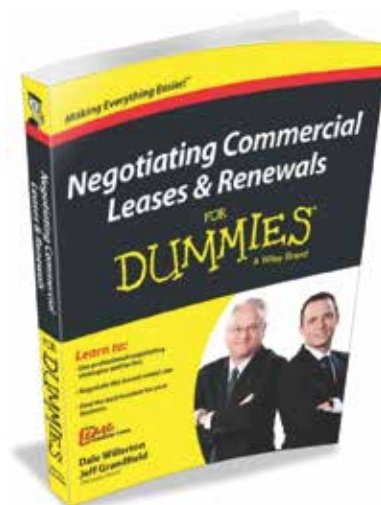
In one property we noticed that the property manager's salary was included in the tenant's operating costs. The landlord, however, refused to reveal the amount of that salary. We forced their hand and discovered that the property manager's salary was ridiculously high. It wasn't the category or the fact of the salary itself was inappropriate – just the amount.

Operating cost discrepancies come in two flavors: honest mistakes or dishonest calculations. In a building where the property is fully or close to fully occupied, the landlord may have less reason to try to profit from operating costs but may still try to enhance the property using the tenant's money. However, when a property has several vacancies, the landlord may want to avoid paying his proportionate share of operating costs for the vacant units. Therefore, the landlord may include language into the lease agreement stating that all of the operating costs will be passed on to the few tenants occupying the building. In some situations, tenants can be left carrying a very heavy burden if the property is not fully leased.

Communication with the landlord (both verbally and in writing) about any operating cost concerns you may have is imperative. And don't wait too long because the lease may stipulate a statute of limitations on adjustments. Sometimes the problem originates with the property manager, but sometimes it comes from the landlord or owner taking advantage of the tenants. If you catch your landlord with his hand in the cookie jar, don't be surprised if he's not cooperative or communicative.

For a copy of our free CD, *Leasing Do's & Don'ts for Commercial Tenants*, please e-mail your request to DaleWillerton@TheLeaseCoach.com.

Dale Willerton and Jeff Grandfield - The Lease Coach are Commercial Lease Consultants who work exclusively for tenants. Dale and Jeff are professional speakers and co-authors of Negotiating Commercial Leases & Renewals For Dummies (Wiley, 2013). Got a leasing question? Need help with your new lease or renewal? Call 1-800-738-9202, e-mail DaleWillerton@TheLeaseCoach.com or visit www.TheLeaseCoach.com.



What an Ounce of Prevention can do for your Practice

Maggie Green and Brian Gomes



Brian Gomes is the President and Chief Executive Officer of BMS Canada Risk Services Ltd. (BMS Group). He works with many of the country's largest healthcare associations to design and provide customized member insurance programs for over 300,000 Canadian regulated health professionals. Brian has more than a decade of industry knowledge and experience and is frequently consulted to discuss and present on the topic of liability and group risk structures. With several designations, he is considered a national and global expert in the field of medical malpractice and professional liability.



Maggie Green is a registered healthcare professional with a Masters in Healthcare Quality, Risk and Safety, Maggie has over a decade of experience in the healthcare sector. She is a frequent speaker on professional liability, risk management, patient safety, and medico-legal trends in practice. As National Practice Leader for BMS Group, Maggie delivers customized claims and risk management services to healthcare organizations and their members.

As an optometrist, you require professional liability insurance in order to register with your regulatory College. We all know that. But when you purchase your coverage, do you think about why you need it, and how important it really is to the future of your practice? Do you know the details of the insurance you are purchasing? Are you sure you're adequately covered and that you have the appropriate limits in place to respond to a claim?.

Insurance and liability are complex subjects as are the offerings and policies that support them. It is important that you understand the differences between the different insurance options available in order to identify the most appropriate coverage for your practice circumstances. Although insurance is something we hope we never need, it is important to ensure we have the right coverage in place before we actually need it.

Professional Liability Insurance (PLI):

Regular interaction with patients is a consistent part of any optometric practice and is a daily occurrence. With this in mind, you may face situations where your patients look to hold you responsible for injuries they deem to have received.

Professional Liability insurance (PLI) protects you against liability or allegations of liability for injury or damages that have resulted from a negligent act, error, omission, or malpractice that has arisen out of your professional capacity as an optometrist. Regulatory bodies of optometry require that every licensed optometrist who provides services, whether in a paid or volunteer capacity, be covered by professional liability insurance. PLI protects optometrists by ensuring that your legal defence is coordinated and paid for if a claim is made against you. Your PLI also covers the cost of any patient compensation, or damages. This means that your patients are also protected; because having PLI means that money is in place to compensate them for valid claims.

While your regulatory body requires that you hold professional liability insurance, there are also other factors to consider: Are you a business owner? Do you have employees? Do you have contents to protect? If so, you should consider supplementing your individual Professional Liability Insurance with other coverage to protect your business name, property and contents.

Business Professional Liability Insurance:

Business PLI provides a separate limit of liability to protect your business assets in the event that your business name is included in a statement of claim or lawsuit. In the event of an incident, the patient will most likely name not only the individual optometrist, but also your business as the larger provider of services. Business owners should consider purchasing Business PLI if other optometrists (for example, co-owners, employees, associates) are billing under the business name. Please note that coverage should be purchased by one individual on behalf of all business owners, employees, and /or the business entity.

If you work independently or are a sole proprietor with no other optometrists billing under your business name, your CAO individual PLI policy will automatically extend to cover your business name.

Note that for the purposes of the CAO policy, you do not need to purchase Business PLI if your regulated health professional staff consists exclusively of opticians, nor do you need to purchase Business PLI for administrative or support staff.

Commercial General Liability Insurance (CGL):

Commercial general liability (CGL) insurance protects you against claims arising from injury or property damage that you (or your business, including your staff) may cause to another person as a result of your operations and/or premises. For example, a patient may fall and injure themselves on a wet floor in your office and look to hold you or your business responsible (they have experienced a bodily injury as a result of your premises). That's why CGL is so commonly referred to as "slip and fall" insurance.

CGL coverage is recommended for optometrists who own or operate clinics. This coverage is also recommended for independent practitioners who contract out their services or bill under their business name. As an example, if you are an independent contractor and accidentally cause damage to the property in which you are working, the property owner may look to hold you responsible for compensating them for the costs of repairs. Your CGL policy would respond under these circumstances.

Property Coverage, Crime Coverage, Clinic/Business Package:

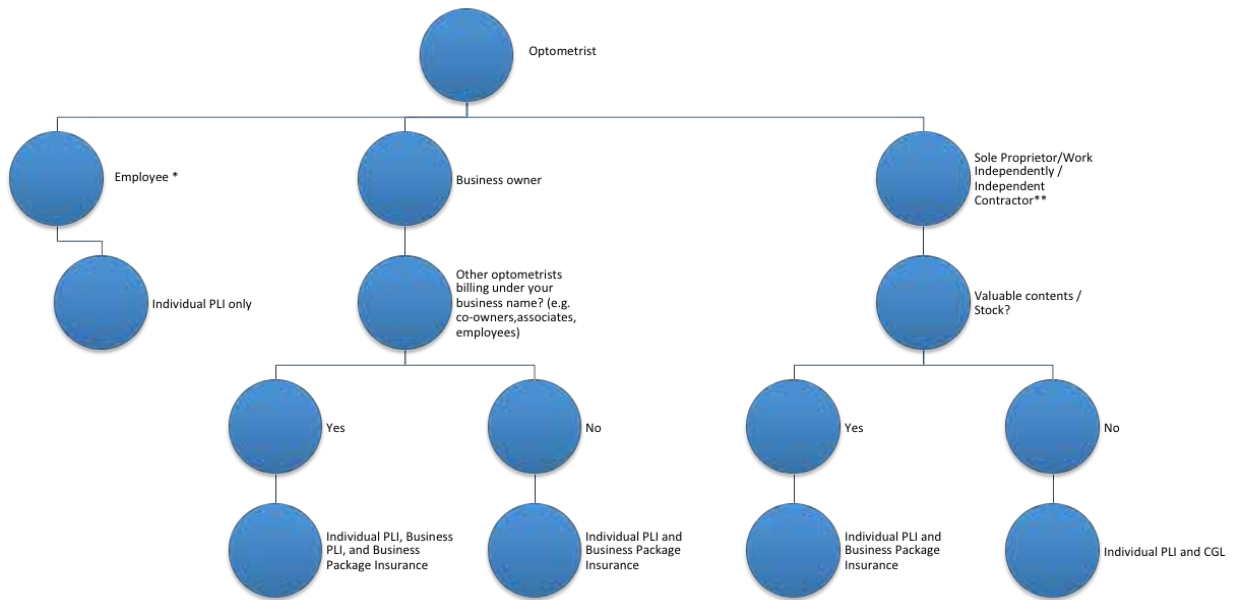
Property Coverage and Crime Coverage protect your business and the contents within from losses associated with property damage (such as fire) and crime. Property Coverage insurance protects against damage to property, including professional equipment, and loss of revenues caused by an interruption of business activities arising from an insured loss. Crime Coverage insurance protects against financial loss due to dishonesty, fraud, or theft of money, securities or other property owned by the business/office.

The CAO program offers a Clinic/Business Package, which includes Property Coverage, Crime Coverage, and CGL insurance. Alternatively, members are able to purchase stand-alone CGL insurance.

Now that you are familiar with the professional liability and business insurance options available, you can use the following hierarchy chart to assist in identifying the insurance coverage that may best suit your practice circumstances.

Please note that this chart provides an outline of common practice scenarios only and does not include all possible professional and business structures. It provides an initial framework for decision-making but should not be considered comprehensive broker advice, nor should it be relied upon as such. You should always speak with an insurance professional at BMS Group to determine the most appropriate coverage for your specific practice circumstances.

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Insights from the 34th Biennial CAO Congress 2015

Pauline Blachford



Pauline Blachford consults optometrists on how to reduce unbooked appointments, increase eyewear sales, and improve employee productivity. She has abundant experience in the eye health industry, including 17 years at White Rock Optometry in BC. Pauline frequently presents at optometry conferences and is a regular columnist for the CJO. For more information, visit paulineblachford.com.

Interesting new people, dynamic presentations, a charming city, and a pound and a half of lobster! Unless you're allergic to shellfish, it doesn't get much better than that.

I had a great time at the CAO Congress in July and found it very intellectually stimulating.

In this article, I share some of the insights I gleaned from attending the sessions, touring the Optofair, chatting with new people I met, and giving two presentations to fun and engaged audiences. Given that I consult optometrists on how to manage and grow their practices, I was particularly alert to information that could help optometrists achieve their business goals and live fulfilling professional lives.

BUILD YOUR TEAM

I was pleased to see that Crystal Clowater presented on employee engagement and team productivity, as these are topics I often address with my clients. In her presentation "The Spirit of Teamwork," Crystal, who is the office manager for Spectrum Vision Clinic in New Brunswick, cautioned that when staff members become trapped in task-oriented patterns, they become less creative and lose sight of their role within the larger team. This is when conflicts arise.

Crystal encouraged her audience to create work cultures in which team members love their work, understand their role, take pride in what they do, and receive praise for their contributions. She noted that businesses that build this type of work culture experience less employee turnover.¹

IF YOU RECOMMEND IT, SELL IT

As I toured the Optofair, I was reminded of a recommendation I often give my clients: if you find yourself frequently recommending a product—for example, omega 3 supplements or Systane eye drops—you should probably be selling that product.

I hold this belief for two reasons. First, as patients come to realize that optometrists do a whole lot more than test vision and prescribe lenses, it's only natural that they come to expect optometrists to offer the products that support the other services that optometrists provide. "If my optometrist can help me prevent glaucoma disease or treat my dry eyes, why can't I purchase the products that will help me avoid or treat those diseases from her clinic?"

The second reason is psychological. We want our patients to view our clinic as a one-stop-shop for all their vision health needs, from having their eyes examined, to receiving a prescription, to purchasing the product that has been prescribed. If you don't want your patients taking their prescription elsewhere to purchase their eyeglasses, why would you reinforce such behaviour when it comes to purchasing the other products you prescribe?

BE PRESENT AND LAUGH MORE

I attended two presentations related to improving clarity of mind and reducing stress, important topics for individuals who juggle the responsibilities of being a doctor and managing a business (not to mention personal obligations). In the first of these presentations, Dr. Bill Cook posited that we spend 40% of our time thinking about the past, 50% thinking about the future, and only 10% living in the present. This leads to stressing over what has passed and pondering future events that may never occur, while missing out on the realities and joys of today. Dr. Cook told us that learning to spend more time in the present (being “mindful”) requires practice, which is done through meditating. While I am not experienced in mindfulness or meditation, it’s something I hear more and more about, and there is no shortage of research on the health benefits.²

In the second presentation entitled “Laughter for the Health of It,” Dr. Barbara Cull-Wilby maintained that laughing can lead to happiness, gratitude, and radiance. If you can’t find time to watch reruns of Friends, Dr. Cull-Wilby says to fake-laugh as a means of getting started. While it may sound too simple to be true, if Dr. Cull-Wilby is correct about the benefits, maybe laughter is the best medicine.

EMPOWER YOUR LINCHPINS

Every time I present at an optometry conference, I marvel at the number of highly engaged optometric staff in the audience. My audiences at this congress were no exception. Most of the attendees took notes and participated in my presentations, and I received a number of thoughtful questions during my Q & As. After my presentations were over, some attendees approached me to ask specific questions about how they could help their clinics reduce unbooked appointments and increase eyewear sales.

I love interacting with these types of people. I refer to them as “linchpins,” a term coined by the business thought leader, Seth Godin. A linchpin is someone who does not just complete assigned tasks, but rather uses her unique skills and abilities to identify and execute potential improvements. If you have a linchpin on your staff, seek her insight, empower her to propose and implement new ideas, and keep her stimulated with more training and learning opportunities.

LOOK TO THE FUTURE

In helping my clients fill their schedules, eventually we are forced to consider what happens when the clinic’s schedule is fully booked. “If it takes a new client more than two weeks to get an appointment,” I caution, “you’re building the client base of the clinic down the street.” Taking on an associate (or another associate) is one way to solve this “problem.” But deciding to do so is not a decision to take lightly. Quality control, mentorship, and other managerial responsibilities are time consuming, and they are tasks that some people just don’t like doing. But new associates can also provide a host of benefits, including increased revenue, an influx of energy and new ideas, and a wonderful opportunity for experienced optometrists to pass on their wisdom to the next generation.

For those who do decide to take on a new associate, the future is bright. During the congress, I had the pleasure of meeting Samantha Menzies, Phyllis Ho, Jeffrey Lam, Jonathan Dinh, and Abraham Yuen, all of whom are recent graduates or current students at the University of Waterloo, School of Optometry & Vision Science. They are mature, intelligent, keen, and fun to be around. The clinics that scoop up these young optometrists will be lucky to have them. And I look forward to working with them in the future.

In conclusion, it was a thought-provoking and inspiring conference. Big thanks to the co-chairs, Dr. Lil Linton and Dr. Ron Harding, and the Local Arrangements Committee, which included local optometrists Drs. Amanda Bartlett, Marisa Blanchard, Lisa Bock, Amanda Brown, Les Clements, Pat Clements, Brian Dalrymple, Neema Patel, Harry Bohnsack, Tara McCarthy, Mel Soicher, Tom Hickey, Mark Inman, Michelle Lane, Richard Lee, Michele Leger, Bronwyn Mulherin, Calvin Smith, and Tim Wiley. Mimi McLaughlin and Nettie Whitlock worked closely

with the CAO staff and the Congress chairs/Local Arrangements Committee. Thank you as well to the CAO staff which included Laurie Clement, Debra Yearwood, Catherine Heinmiller, Doug Dean, Helen Bouchard, and Danielle Paquette.

I look forward to doing it again in Ottawa in 2017.

REFERENCES

1. For more information on how to reduce employee turnover, see my article “Reducing Employee Turnover” in the Canadian Journal of Optometry 2014;76(2):29.
2. For a synopsis, see Time Magazine cover stories “The Science of Meditation” (August 2003) and “The Mindful Revolution” (February 2014).



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Wavefront Aberrations in Subjects Wearing Soft Aspheric Contact Lenses and Those Wearing Spherical Ones

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Abstract

Purpose: To measure the level of higher order aberrations (HOA) when wearing a soft aspheric contact lens (CL), compared to a spherical CL, in myopic subjects. **Method:** Fifteen myopic subjects aged 20-30 years were tested for the presence of dry eye. Aberrometry measurements were done without a contact lens as well as with a spherical CL and an aspheric CL. Root mean square error (RMS) of HOA, spherical aberration (SA) and coma were measured five times in an interval of 15 seconds without blinking for each of the 3 conditions. **Results:** Wearing a spherical CL produced a significant increase of SA and horizontal coma compared to an eye without a contact lens. When wearing an aspheric CL, there was a trend towards a smaller increase of these aberrations. However, the difference between both types of lens was not statistically significant. In terms of total HOA, these were higher when wearing the spherical CL, while they tended to be less with the aspheric CL. As for the variations between blinks, there was a similar increase in total HOA and individual modes with time for the three conditions. **Conclusion :** Wearers of aspheric CL seem to show a tendency towards smaller amounts of SA, horizontal coma and HOA in general in comparison with wearers of SCL. However, total HOA increases during a long interval between blinks, no matter the condition

KEY WORDS:

soft CL, aspheric CL, higher order aberrations, spheric aberrations, coma

Sommaire

Objectif : Mesurer le niveau des aberrations d'ordres supérieurs (AOS) lors du port d'une lentille cornéenne (LC) souple asphérique, par rapport à une LC sphérique, chez des sujets myopes. **Méthode :** Des mesures de sécheresse oculaire et d'aberrométrie ont été effectuées sur un échantillon de 15 sujets myopes âgés de 20 à 30 ans. L'aberrométrie était mesurée dans trois conditions : 1. avec une LC sphérique, 2. asphérique ou 3. sans LC. Pour chacune de ces trois conditions, la racine des moindres carrés (RMC) des AOS, l'aberration sphérique (AS) et la coma ont été mesurées à cinq reprises dans un intervalle de 15 secondes durant lequel le sujet devait s'abstenir de cligner des yeux. **Résultats :** Les AOS augmentent lors du port d'une lentille sphérique. Avec les LC asphériques, l'augmentation des AOS tend à être plus faible. La LC sphérique provoque une augmentation significative de l'AS et de la coma horizontale par rapport à la condition sans LC. Pour la LC asphérique, on note une tendance

vers une progression moins importante de ces aberrations, quoique les différences entre ces deux types de lentilles ne soient pas statistiquement significatives. Quant aux variations inter-clignement, il y a une augmentation semblable des AOS et des modes individuels dans le temps pour les trois situations. **Conclusion :** Il y a une tendance vers moins d'AS, de coma horizontale et d'AOS en général lors du port d'une LC asphérique par rapport au port d'une lentille sphérique. Par ailleurs, toutes les aberrations mesurées augmentent lors d'un intervalle prolongé entre les clignements, peu importe la condition testée.

INTRODUCTION

Since the end of the 1990s, interest in improving the optical quality of the eye has grown. In order to improve visual performance, contact lens (CL) companies have developed so-called “high-resolution” CL that are supposed to correct the spherical aberration (SA) in addition to correcting the refractive error (myopia, hyperopia) and astigmatism. A reduction in aberrations ensures better imagefocus. As demonstrated in the past, the SA inherent in the optical system of the eye affects 90% of the population and introduces, on average, 0.15 μm of positive aberration.¹ SA is one of the many forms of wavefront aberration that affects the human eye. It has also been established that, for a person wearing CL, vision quality is affected, not only by the optical system of the eye, but also by the optical properties of the CL, as well as by the interaction of the CL with the eye, particularly with respect to the cornea and the tear film.² Thus, it would be pertinent to study the effect of aspheric CL on various types of aberrations.

Using a wavefront analysis, two recent studies demonstrated that certain types of soft spherical CL used to correct myopia increase total HOA, compared to when CL are not worn.^{2,3} In 2003, Lu et al. also demonstrated that subjects wearing soft, spherical CL have more HOA on average than those who do not wear CL. However, they also noted a great amount of variability with respect to these aberration changes among CL wearers. These authors are of the opinion that, given the significant individual variations, the correction of aberrations with CL should be done on a personalized basis.⁴

The eye does not have an aberration-free optical system, and the wavefront resulting from the passage of light through the various ocular media undergoes deformations. In optics, the deformations of the sphericity of the light wavefront that reaches the retina are called aberrations. As a result of these aberrations, the image the eye produces of a point object is no longer a point but, rather, an irregularly shaped spot.

The most common method for representing wavefront aberrations is the Zernike polynomial. According to this model, the various types of aberrations are represented by modes that are inserted inside the various orders and are quantified by the coefficient of these modes. The sum of these individual modes forms the polynomial. Orders of three and more are qualified as higher orders. The most notable of these modes are the vertical and horizontal comas, the trefoil, and the SA. One of the most commonly used indicators for total aberration of the eye is the root mean square (RMS). The RMS is defined by the square root of the sum of the square of the Zernike coefficients. A high RMS generates a reduction in optic quality. Naturally the aberrations between the two eyes are generally substantially symmetrical.^{10,11}

The tear film is important for protecting the surface of the eye, but also for ensuring a quality optical surface.⁵ It represents the most powerful optical surface of all the ocular dioptrics, as a result of the significant difference in the refractive index between the air and the tears.⁶ As a result, a slight variation in thickness or regularity will produce significant aberrations. Therefore, maintaining a uniform tear film is essential for providing a high-quality retinal image.^{6,7} Montés-Micó et al. demonstrated that, after blinking, the tear film quickly stabilizes, which causes a reduction in higher order aberrations. Following this, they start to increase, following the evaporation of the tears, which results in an irregularity and then the disruption of the tear film.⁸ In their study, which was published in 2005, the minimal quantity of aberrations was measured at 6.1 ± 0.5 seconds after blinking, on average, in normal subjects.⁸

Koh et al. demonstrated that it is possible to classify the temporal changes in the total HOAs that occur after blinking in four models: the stable model, small fluctuation model, sawtooth model, and other models.⁵ At the same time, if an aspheric CL that includes a correction is poorly centred, it could cause a non-negligible quantity of coma.⁹ Since we know that the eyelids close in a lateral progression, moving from the outer canthus to the inner canthus, we know the effect of gravity, and we know that the apex of the cornea is decentred temporally in most individuals, it is to be expected that the CL is not perfectly centred and that its position varies in the interval between blinks.⁹

The HOA degrade the quality of the retinal image. The SA causes a circular halo around the image while the coma gives the image of a point a comet-like tail shape. This results in a trailing blur next to the image, parallel to the symmetry axis of the “tail.” The influence of these two aberrations depends significantly on the diameter of the entrance pupil of the optical system. The SA and the coma are generally the two most noted HOA in the human eye.

The purpose of this study is to measure the level of HOA in subjects with myopia when wearing a soft aspheric contact lens (CL), compared to a spherical CL, particularly during the interval between blinks.

The first hypothesis presented in this study is that wearing a spherical CL will cause an increase in the HOA in most subjects. Then, when aspheric CL are worn, the SA will be reduced, as compared to wearing spherical CL. Finally, the HOA present between blinks will also vary in keeping with the capacity of the CL to maintain the regularity of the tear film on its surface and also in keeping with the nature of the optic design.

MATERIALS AND METHODS

SUBJECTS

Fifteen subjects aged 20–30 years were recruited to test the hypotheses. The characteristics of the subjects are provided in Table 1. The subjects had to be CL wearers and have myopia with a spherical equivalent between -1.00 D and -7.50 D. The astigmatism could not exceed one-quarter of the sphere. The subjects did not present any ocular pathology and had not undergone surgery or refractive surgery that could have modified the integrity of the cornea.

With respect to the CL, two ocuflcon D CLs (gr. 1 of the FDA classification) with 55% water content were used. Only the optical design differed: one was spherical and the other was aspheric.

Demographic data for the sample

Data	Age	Myopia	Astigmatism	Meridian K flat	Meridian K steep	Pupil diameter
Average	22.9 yrs	-3.48D	-0.2D	43.38D	44.00D	5.96mm
Standard deviation	±1.44 yr	±2.03D	±0.34D	±1.36D	±1.49D	±1.10mm

Tableau 1. Demographic data for the 15 subjects that completed the study.

INSTRUMENTS AND PROCEDURES

During the first visit, each subject was evaluated to confirm that they satisfied the inclusion criteria. This evaluation involved a subjective refraction and a biomicroscopic examination of the anterior and posterior segments of the right eye, since only the right eye was tested. The keratometry and fit of the CL were also verified, only in the right eye, using a biomicroscope.

At the end of this visit a quantitative evaluation of the tear film was made. The volume of tears was measured with cotton threads calibrated for this purpose (Zone-Quick™, Menicon, Japan). Then the tear film break-up time (TBUT) was evaluated with fluorescein by observing the subject's eye with a biomicroscope and a yellow filter.

During the second visit, aberrometric measures were taken with the Nidek OPD-Scan II™ optical path difference scanning system (Nidek Co., Japan). This diagnostic instrument is an auto-refractometer, a corneal topographer, and an aberrometer. This tool was used to make a quantitative analysis of the light wavefront reflected by the retina after passing through the ocular dioptrics and media. These measurements were taken without pupil dilation. The NIDEK OPD-Scan II™ consists of two main systems. The projection system consists of an infrared beam that passes through a wheel equipped with a slit that produces light beams in the direction of a lens and mirrors. The wheel turns constantly at high speed, so as to cover the 360° of the pupil. The light beams enter the eye and are then reflected by the retina to head outside the eye toward the detector system. Finally, these rays cross through another lens and are then captured by an array of photodetectors.

The difference in the amount of time it takes the light to reach the central photo-detectors and the peripheral ones is converted into refractive power. This movement from the centre to the periphery is similar to that of the standard retinoscope used in clinics to objectively measure the ocular refractive error. The projection and detector systems turn in a synchronized manner around the optic axis of the device in order to measure the refraction of each meridian in increments of one degree.¹³ This instrument acquires 1,440 data points that describe a refraction map through the pupil.¹⁴ This map is converted into a map of the wavefront error through the pupil. This device was designed for clinical use.

The first step involved qualifying the reliability of this aberrometer. This validation was made with a sub-group of five subjects, given the limited amount of time allocated for this study. For this, three aberration measurements were made, without a CL, over two days.

Then, for each of the subjects, the ocular aberrations were measured without a CL. Then measurements were made with spherical and aspheric CLs, in turn. The CL was inserted in the eye at least five minutes before the measurements were taken. This period of time stabilized the tear film and the CL on the eye. Every time a measurement was taken using the aberrometer, the subject had to blink three times, stare at a target, and keep their eyes open until the measurements were completed (15 seconds). Half the group started with the spherical CL and the other half with the aspheric CL. Measurements for each of the three conditions were repeated three times. The aberrometer isolated the RMS values for the various aberrations that comprise the wavefront. The values for the vertical coma, horizontal coma, SA and total HOA were extracted for the analysis.

Data were analyzed with the SPSS™ 17.0 statistical application for Windows™. General linear models were used to test the possible significant differences in the data collected in keeping with the “aberration type,” “correction type,” and “time” factors. When applicable, post-hoc comparisons between the various CL conditions were made using paired tests on the estimated marginal averages (with a Bonferroni adjustment for multiple comparisons). If the general linear model revealed no time variation, the estimated marginal averages were only compared at the sixth second (time when the tear film is generally more stable⁸). If that was not the case, these paired tests were made every three seconds during the 15-second interval during which the subject was not to blink. A coefficient value of $p < 0.05$ was considered significant.

RESULTS

RELIABILITY

First, the Nidek OPD-Scan II™ aberrometer produced reliable results. For example, for four of the five subjects tested during two different days, the difference in the numerical values obtained for the SA between the two sessions did not exceed 0.05 μm . This was not clinically significant.

ABERRATION MEASUREMENTS DURING THE INTERVAL BETWEEN BLINKS

The averages and standard deviations of the aberrations studied for the three CL wearing conditions are reported in Figures 1–3. The average pupil dilation during the measurements was 5.96 ± 1.10 mm.

a) Spherical aberration

With respect to the SA, the general linear model analysis revealed that this aberration did not vary more over time for the three conditions during the 15-second interval ($p = 0.491$).

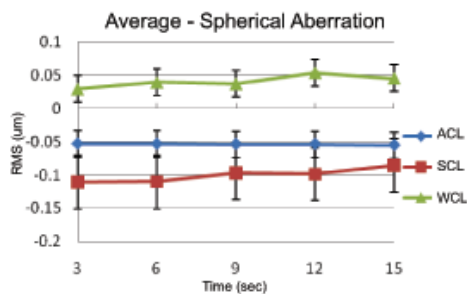


Figure 1. Evolution of the average ($n=15$) of the spherical aberration during the 15-second interval during which the patient had to keep their eyes open while wearing no CL (green triangle), wearing a spherical CL (red square) and wearing an aspheric CL (blue diamond). The error bars correspond to the standard deviation.

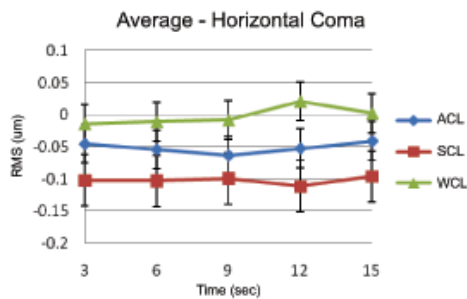


Figure 2. Evolution of the average ($n=15$) of the horizontal coma during the 15-second interval during which the patient had to keep their eyes open when wearing no CL (green triangle), wearing a spherical CL (red square) and wearing an aspheric CL (blue diamond). The error bars correspond to the standard deviation.

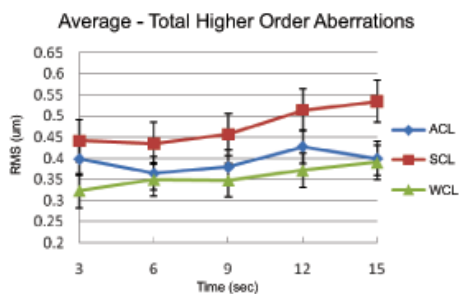


Figure 3. Evolution of the average ($n=15$) of the total of the higher order aberrations during the 15-second interval during which the subject had to keep their eyes open when wearing no CL (green triangle), wearing a spherical CL (red square) and wearing an aspheric CL (blue diamond). The error bars correspond to the standard deviation.

At the sixth second, the estimated marginal averages presented a statistically significant difference ($p < 0.0005$) between the condition without CL and the condition with a spherical CL ($p = 0.008$) or with an aspheric CL ($p = 0.001$) (Figure 1). The average SA measured in the subjects not wearing CL was $+0.040 \mu\text{m}$, compared to $-0.110 \mu\text{m}$, after a spherical CL was inserted. However, the comparison of the estimated marginal average pairs revealed no significant difference between wearing a spherical or aspheric CL ($p = 0.486$). Nevertheless, the aspheric CL did show a tendency to reduce the total SA (eye + lens), compared to the spherical lens. However, the average SA was the least when no CL was worn.

b) Coma

No change in terms of time for the three conditions was observed for the horizontal coma (general linear model; $p = 0.649$).

Analysis of the estimated marginal averages, at the sixth second, revealed a significant difference between the result obtained without a CL and that obtained with a spherical CL ($p = 0.025$) (Figure 2). The spherical CL tended to produce a higher amount of horizontal coma, compared to the aspheric CL. However, the horizontal coma with the spheric CL was not significantly different compared to that of the eye without a CL ($p = 0.074$). Moreover, a general linear model revealed no statistically significant differences for the vertical coma for the three CL conditions ($p > 0.05$).

c) Relationship between the spherical aberration and the horizontal coma

Analysis of the Pearson correlation coefficient revealed an association between the SA and the horizontal coma with no CL and with a spherical CL. Table 2 indicates the determination coefficient (r^2) observed in these conditions for each time sampled. For the condition with no CL, all of the correlations in this table were statistically significant, except for the 12th second of the situation without CL. That correlation is, however, in keeping with the other values. All of the corrections with a spherical CL were statistically significant. However, because no correlation was significant in the presence of an aspheric CL.

d) Total higher order aberrations

Finally, with respect to the progression of total HOA over time, a general linear model indicates the existence of a significant variation ($p = 0.013$) for the total average HOA for the three conditions. The pair comparison (estimated marginal averages) served to establish that the change occurs between the sixth second and the fifteenth second ($p = 0.008$) as well as between the ninth and the fifteenth seconds ($p = 0.007$).

Correlation between the Spherical Aberration and the Horizontal COMA (R^2)			
	No contact lens	Spherical contact lens	Aspheric contact lens
3rd second	0.647**	0.694**	0.403
6th second	0.586*	0.736**	0.424
9th second	0.544*	0.772**	0.343
12th second	0.454	0.770**	0.465
15th second	0.519*	0.798**	0.476

***The correlation is significant at 0.05 (bilateral)**
****The correlation is significant at 0.01 (bilateral)**

Tableau 2. Pearson correlation coefficients for the relationship between the spherical aberration and the horizontal coma every 3 seconds of the 15-second interval during which the subject had to keep their eyes open when wearing no CL, wearing a spherical CL and wearing an aspheric CL. The table indicates the strength of this relationship in the three conditions tested.

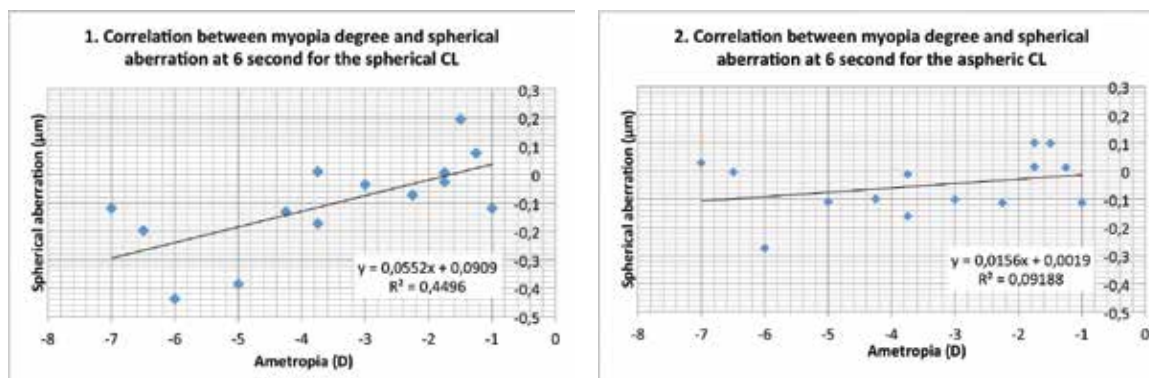


Figure 4. Relationship between the subjects' ametropia ($n=15$) and the total spherical aberration (eye plus CL) at the 6th second of the 15-second interval during which the subject had to keep their eyes open when wearing the spherical CL (1) and the aspheric CL (2).

The general linear model for the total quantity of HOA demonstrated a significant difference between the three CL-wearing conditions ($p = 0.021$) (Figure 3). However, the paired comparisons (estimated marginal averages) do not reveal significant differences between the CL-wearing conditions ($p > 0.05$). When an aspheric CL is worn, the average HOA seemed to be similar to that when no CL is worn, while there were more aberrations with the spherical CL.

DISCUSSION

The average SA measured in the subjects without CL was $+0.040 \mu\text{m}$ at the sixth second (time when the tear film was the most stable⁸) (Figure 1). This value is below the average SA found in most of the population, namely $+0.15 \mu\text{m}$ positive SA.¹ Therefore, the SA seems to be positive in the mostly myopic subjects who took part in this study. After a spherical CL was installed, the average SA was $-0.110 \mu\text{m}$. Therefore, this type of CL introduced a statistically significant negative SA in the sample studied, which is in keeping with the predictions of geometric optics. Based on our results (Figure 4), it seems that the more negative a spherical CL is, the more negative the total SA (eye and CL) is (although the correlation is average, with a coefficient of determination of $R^2 = 0.4496$). This relationship is weak in the case of the aspheric CL with $R^2 = 0.09188$ and is not significant ($p > 0.05$).

Any spherical minus lens produces a negative SA on its own. However, if we consider only the tendency concerning averages, the aspheric CL produces less negative SA ($-0.053 \mu\text{m}$), compared to the spherical CL. Therefore, it is possible to suppose that the designers of the spherical CL gave a negative or neutral SA correction value for low myopic corrections, knowing that the SA of the eye (positive) added to that induced by the concave nature of the CL would remain positive. In keeping with the concepts of geometric optics, it is likely that the aspheric CL designers calculated the negative value of the spherical aberration of the CL that corrects the myopia, so that it would complement the generally positive spherical aberration of myopic eyes.

As for the aspheric CL of medium or high minus power, the SA correction of the CL complements the increasingly negative SA produced by the increase in the concave power of the lens. Without this positive correction, the amount of SA produced by the lens would be so high that it would shift the total SA of the eye/lens pair toward the negative. Thus the aspheric lens would be designed to induce the necessary quantity of SA to cancel out the quantity usually produced by the power of the lens on its own.¹⁵ For this reason, the inversion of the sign of the SA induced may be observed in the five subjects wearing CL with a power greater than or equal to -5.00 D.

Moreover, according to Figure 1, the SA becomes more negative, on average, for the subjects with spherical CL. When the subject wears an aspheric CL, this aberration decreases in absolute value but is not the same as the values obtained without a CL. This confirms the initial hypothesis resulting from the hypothesis that the total SA could be better controlled with an aspheric lens. Nevertheless, this study does not confirm that the aspheric CL provides statistically significant results.

It should be noted that aspheric CL designers are targeting a theoretical SA. In fact, it is possible that the SA of the eye in certain subjects may be different from the proposed average value. Thus it is possible that, for these subjects, the SA may be worse or may not improve with the aspheric CL, compared to that measured with a spherical CL.

The results for the horizontal coma demonstrated a statistically significant increase for subjects wearing a spherical CL, compared to those wearing no CL (Figure 2). Two main factors seem to influence the amount of horizontal coma: the quantity of SA induced by the CL and lens decentring. As indicated above, high minus powers cause a transfer of the SA toward negative values when the subject wears a spherical SA. Also, the visual axis is generally off axis by 1/4 to 1/2 mm nasal, with respect to the pupillary axis (angle Kappa). A CL would tend to centre itself on the corneal apex, since it is usually temporal with respect to the visual axis. Therefore, when a subject looks through a CL along their visual axis, they are not exactly centred on the optical axis of the CL.

The SA of the CL combined with the decentring of the CL, compared to the optical system of the eye, could produce the horizontal coma. The stronger the spherical lens power is, the more SA it induces and the more the decentring will induce a significant amount of horizontal coma. This relationship accounts for the correlation between the SA and the horizontal coma for subjects wearing spherical CL (Table 2). This same correlation is found, although to a lesser extent, when the subjects do not wear CL.

According to the results, horizontal coma tends to be less when the subject wears an aspheric CL than when wearing a spherical CL. In fact, the SA is lower when the subject wears an aspheric lens than when wearing a spherical lens and, therefore, less horizontal coma is produced by decentring, due to the angle between the corneal apex and the visual axis. When considering only the numerical values obtained, the horizontal coma remains at a minimum when the subject wears no CL.

Since the visual axis and the apex are decentred on a horizontal plane, rather than a vertical one, the same tendency was not observed during the study of the vertical coma. Therefore, no significant trend for this aberration was observed.

During the analysis of the quantity of total HOA, no significant difference was noted following the paired comparison of the three conditions (Figure 3). It is, however, possible to observe a difference at the limit of statistical significance ($p = 0.054$) between the average HOA present when the subject wears a spherical CL compared to when they wear no CL. The spherical CL induces a higher quantity of HOA during the entire interval between two blinks. Nevertheless, neither of the two methods of correction is preferable for slowing the increase in the quantity of HOA, because the time following blinking increases. A significant increase in HOA was demonstrated for all of the conditions by comparing the results for the sixth and the ninth seconds for those observed at the fifteenth second. In keeping with the average TBUT of the subjects (seven seconds after the blink), this increase could be attributable to a thinning of the tear film following the break-up. The quantity of HOA induced certainly helps to reduce visual quality during a task involving a lot of concentration. To sum up, neither of the two CLs tested helps control the HOA.

CONCLUSION

In this study, the two types of CL (spherical and aspheric) increased the quantity of SA, horizontal coma, and total HOA in the subjects. However, wearing an aspheric CL tends to reduce the quantity of all the aberrations studied, compared to wearing a spherical CL. The aspheric CL is particularly beneficial for subjects with myopia of more than 5 D., wearing spherical CL, since these lenses induce an important quantity of negative SA and, possibly, horizontal coma. The SA and the coma do not vary significantly between blinks. However, the total HOA increased significantly during the interval between them. It could be interesting to reproduce this study with a CL made of a material that does not dry so rapidly, so that the HOA remains stable over time. In a future study, it could also be interesting to set up two separate groups, one with dry eyes and one with normal eyes, so as to better define the relationship between eye dryness and wavefront aberrations.

This study was approved by the Comité d'éthique de la recherche des Sciences de la Santé (CERSS) of the Université de Montréal and respected ethical standards with respect to using human subjects for research (principles of the Helsinki protocol). The participants were informed about the nature and details of the project and gave their written consent before taking part.

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