PROCEEDINGS OF THE LATVIAN ACADEMY OF SCIENCES. Section B, Vol. 71 (2017), No. 5 (710), pp. 392–396.
DOI: 10.1515/prolas-2017-0066

Research methods

HOYA EYEGENIUS®: NEW METHOD FOR MEASURING AND CORRECTING FIXATION DISPARITY*

Volkhard Schroth[1], Olga Prenat[2], Natalia Vlasak[3,#], and Roger Crelier[1]

[1] University of Applied Sciences and Arts Northwestern Switzerland, Olten, SWITZERLAND

[2] Hoya Vision Care Europe, Uithoorn, THE NETHERLANDS

[3] Maribor University, Maribor, SLOVENIA

[#] Corresponding author, Natalia.Vlasak@hoya.com

Many things interfere with good binocular vision in nowadays modern digital environment: long periods spent looking at screens and switching between different digital devices at short distances. Vision-related or asthenopic complaints such as headaches, tired and burning eyes or blurred vision can be experienced by many people. Prescribing prismatic correction for fixation disparity can help to reduce these symptoms. A new, highly innovative method for measuring and correcting fixation disparity has been developed — HOYA EyeGenius®. The HOYA EyeGenius® method includes the unique examination procedures, pre-tests and fixation disparity measurements at far and near distances. The pre-tests allow to include patients with asthenopic complaints only with normal binocular vision and exclude cases with abnormal binocular vision. The main innovation of EyeGenius is based on direct conversion of the fixation disparity value into a prism amount. Therefore, the trial prismatic lenses are not used during the test. The use of digital devices makes this method interactive and minimizes the influence of the examiner.

Key words: *EyeGenius, fixation disparity, prismatic correction, aligning prism, asthenopic complaints, binocular vision.*

INTRODUCTION

Typical vision-related or asthenopic complaints such as headaches, tired and burning eyes or blurred vision can be expected in more than 50% of patients even in the age group between 18 and 38 years (Montés-Micó, 2001). Prescribing prismatic correction for fixation disparity (FD) helps reduce these symptoms. A new method has been developed which allows an aligning prism to be determined based on the direct measurement of FD.

HOYA is passionate about binocular vision and devotes a lot of time and attention to the subject. There are many things that interfere with good binocular vision in today's digital environment, such as the increased amount of work carried out at short distances and the need to constantly switch between multiple digital devices. These challenges spurred us to look for a new method for assessing FD.

The result was Hoya EyeGenius®, a highly innovative method for measuring and correcting FD based on direct conversion of the FD value (measured in minutes of arc) into a prism dioptre amount (pdpt). This new interactive measurement solution minimises any influence from the person carrying out the examination. Based on six years of clinical researches, development and testing, Hoya EyeGenius® was developed by HOYA in cooperation with the University of Applied Sciences and Arts Northwestern Switzerland.

FUNDAMENTALS OF HETEROPHORIA AND FIXATION DISPARITY

Binocular deviations were studied and summarised by scientists some 120 years ago: Maddox examined how the vergence system reacted to prisms (Maddox, 1893) while Duane made a classification for convergence insufficiency and convergence excess which has been used ever since (Duane, 1897). These approaches have been and continue to be used to measure dissociated heterophorias, which are defined as deviations from the orthovergence position without fusion.

The term "fixation disparity" (FD) was introduced by Ogle in 1949. In the years since then, dissociated and associated phorias have gradually been differentiated. FD assessments and its clinical value attracted a lot of interest to practitio-

* This is a modified version of the original article which has been published in Optician Journal: Schroth V., Prenat O., Vlasak N., & Crelier R. (2017). Correcting disparity. *Optician*, **253** (6589), 30-33.

ners. FD is defined as a residual misalignment of the foveas within Panum's Area that persists after the vergence system compensates for neuromuscular bias when fusion is allowed (London and Crelier, 2006).

Therefore, FD assessment gives a realistic view of the binocular vision under normal viewing conditions (Jenkins *et al.*, 1989).

FD is more highly correlated to asthenopia than dissociated heterophoria (London and Crelier, 2006) and represents a good indicator of visual system's stress. FD is measured in minutes of arc, and the aligning prism — in prism dioptres (pdptr). FD is counteracted by aligning prisms so that the latter nullify it. Two parameters are required to measure subjective FD (see Fig. 1): the perceived displacement (d) of both nonius lines and the distance between the test plane and the eye of the tested person (s). The formula used to determine FD in minutes of arc is $\tan \alpha = d/s$.

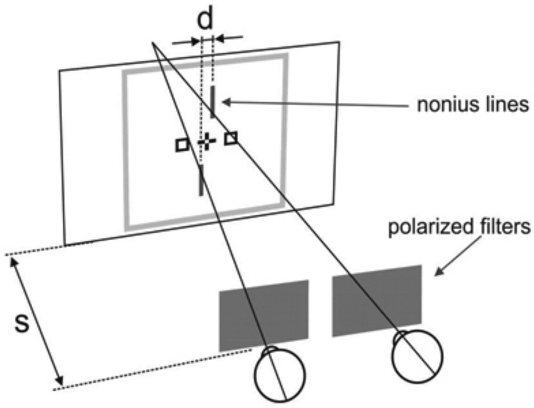

Fig. 1. Test figure to measure FD. The nonius lines are adjustable and the observer has to align them to the central cross. However, on the monitor they are moved around distance (d). The observation distance is marked by (s). The extent of the displacement and the test distance then allow subjective FD to be calculated in minutes of arc.

Binocular correction methods using FD test figures were developed by Haase (1962) and Mallett (1964) more than 50 years ago, and they remain in use in Europe today. Forty years ago in the USA, Sheedy developed test figures based on Ogles' ideas to determine FD curves (Sheedy and Saladin, 1978).

Both, MCH (Haase) and Mallett tests, have been widely used to assess FD. Prismatic corrections have been successfully used in German-speaking countries to treat patients with asthenopic complaints (Günthert, 1980; Methling and Jaschinski, 1996; Schmitz, 1998; Schroth, 1998). Promising results regarding the improvement of reading speed and visual acuity have also been reported in British optometry (Jenkins *et al.*, 1994; O'Leary and Evans, 2006).

The existing methods described above have advantages as well as limitations. The MCH and Mallett methods use conventional procedures to define aligning prisms through the process of measuring associated phorias.

The Hoya EyeGenius® method is based on the direct detection of FD and its precise recalculation into an aligning prism by means of a unique algorithm. This allows values to be defined in increments of 0.01 pdptr, which is impossible with conventional methods. Additionally, modern, electronic visual testing devices are used, which facilitates patient interaction and minimises the influence of the practitioner on the outcome of the test.

HOYA EYEGENIUS® RESEARCH STUDIES

The advantages and disadvantages of prismatic corrections have been debatable among experts. As long as the fusion control circuit is active and works under normal viewing conditions, the wearing of prisms affects the position of rest, the fusional reserves and FD (Cooper, 1992). The prism can therefore be adapted to a wide range. As soon as the fusion is broken up, the eyes slowly return to their original vergence rest position. If the vergence system has a high adaptation ability under normal fusion conditions, small prisms can become ineffective after a long period of wear (this phenomenon is known as the 'eating up' of prisms).

The development of Hoya EyeGenius® started with a study of the effects of wearing prismatic correction using a high-resolution eye tracking device. This research phase was done in the cooperation with Dr. W. Jaschinski from the IfADo Leibniz Research Centre for Working Environment and Human Factors in Dortmund, Germany, and the research group Individual Visual Performance, who have a lot of experience and familiarity with longstanding research on subjective and objective FD. Significant effects on subjective and objective FD after several weeks of continuous prism wearing could be demonstrated for the first time (Schroth *et al.*, 2015). Even small prism values were effective and the outcomes of this study show the evidence that the vergence system does not fully adapt to prisms.

Another important research was done on the correlation between fixation disparity and aligning prism. A preliminary study measuring FD in min of arc was carried out on 40 subjects. Then the prisms were gradually introduced to nullify FD. The amount of the prisms was increased until FD reached zero or its inversion of the direction. All measurements were carried out with a far and a near vision testing device, and both vertical and horizontal FD was measured. This made it possible to calculate an aligning prism from FD with an accuracy of 0.01 pdptr. A high correlation was found between the initial FD and the calculated final aligning prism, $r = 0.79$ horizontally and $r = 0.89$ vertically. The researchers were able to determine conversion factors which made it possible to immediately convert the FD value into an aligning prism. This is the main innovation and foundation of the new Hoya EyeGenius® method, which allows unprecedented rapidity and accuracy of measurements.

THE HOYA EYEGENIUS® METHOD

The Hoya EyeGenius® concept integrates the most important criteria for measurements, making them reliable, easy and fast.

- Pre-tests recognise abnormal binocular vision cases which cannot be assessed by Hoya EyeGenius®.
- In case of unreliable measurement, the system generates a message referring the patient to an extended binocular examination. For instance:
  - Unreliable FD measurement horizontal or vertical, far or near;
  - Difference between far and near FD measurements
  - Detected FD is outside of defined ranges.

  The near tablet serves as a remote control and is used by the patient to align the nonius lines without influence from the examiner.

  The FD measurement takes less than 10 minutes for both far and near distance measurements.

  The measurement is carried out without trial prisms.

  Examiners receive the resulting prisms on their remote control right away. The prisms are prescribed after the subjective trial and acceptance by patient.

THE HOYA EYEGENIUS® SYSTEM

Hoya EyeGenius® is made up of an iPad running the remote control HOYA App, a Far Vision Device and a Near Vision Device (see Fig. 2). These three interconnected devices use Wi-Fi to communicate with each other.

The Far Vision Device (FVD) uses polarisation technology on a 24" LCD screen. It is capable of running a wide range of polarised tests without requiring the addition of a supplementary polarised screen to the basic monitor. The tests are carried out with the appropriate polarised glasses. The system provides high-quality polarisation and an even background and eliminates ghost images, and makes use of the entire surface of LCD screen.

Fig. 2. HOYA EyeGenius® System.

The Near Vision Device (NVD) is 3D and 10.1" in size and is used for near vision examination. It provides high-quality polarisation and an even background and eliminates ghost images, and makes use of the entire surface of LCD screen (3D technology) without the use of polarised filters. The so-called 'barrier technology' uses two displays one in front of the other.

The NVD combines two functions: it is a visual testing device, which displays the test figures necessary for near refraction in 2D and 3D, and can be used by the customer as an interactive tablet computer.

The Remote Control Device is an iPad application named HOYA EyeGenius® available from the Apple Store. The Far Vision Device and the Near Vision Device are controlled directly through the HOYA EyeGenius® software control panel, running on an iPad.

Each step in the test is accompanied by instructions for the examiner, including a script for what to say to the patient.

AVAILABLE TESTS

There are more than 60 optometric tests in the Hoya EyeGenius® system for far and near vision examination divided into four groups: refraction, visual function, binocular vision tests, and the new HOYA EyeGenius® FD test.

The refraction group, for example, contains a variety of different optotypes and tests for astigmatism or binocular balance. There are many different functions, such as choice of a single optotype or rows of optotypes, changes of contrast, red-and-green background or switch to inverse presentation. Users can also choose among a range of randomly generated optotypes.

The visual function tests contain other functions, like contrast measurements, twilight or glare tests, night myopia tests, fixation figures, and so on. The binocular vision tests include the new Mallett test and the whole MCH sequence in line with the directives of the International Association for Binocular Vision (IVBS). The binocular vision tests are available on both far and near vision devices.

Hoya EyeGenius® method for measuring FD

The HOYA EyeGenius® FD includes the unique examination procedures pre-tests and FD measurements, with a high rate of detecting horizontal and vertical values of FD.

Hoya EyeGenius® pre-tests

The goal of the pre-tests is to include patients with asthenopic complaints and exclude all cases with abnormal

Fig. 3. Hoya EyeGenius® asthenopic symptoms questionnaire.

binocular vision. The Hoya EyeGenius® pre-tests consist of the asthenopic symptoms questionnaire, a test for checking monocular visual acuity under binocular conditions, and the random dot stereo vision test at near distance (see Fig. 3).

Patients wear a trial frame during all pre-tests, with far correction for non-presbyopes and near correction for presbyopes. Once all pre-tests have been administered, the examiner is taken directly to the Hoya EyeGenius® FD measurement.

Unique Hoya EyeGenius® test figures

The test figures (see Fig. 4):

- Have a strong central fusional lock (cross and squares), seen by both eyes, to stimulate central fusion;
- Have a strong peripheral fusional lock (letters), seen by both eyes, to stimulate peripheral fusion;

are presented on the left and on the right in order to create natural binocular viewing conditions and for measurements to be taken under dynamic conditions.

The Hoya EyeGenius® FD measurements must be carried out without any prism even if the patient worm or has been wearing prismatic prescription. The method is not designed to allow a summation of prism values.

A sophisticated algorithm using the standard deviation of the test results runs in the background. It analyses far and

Fig. 4. Horizontal FD test figure at far point presented on the right.

near FD measurements to ensure that they have been taken in a reliable manner. When the far and near measurements are comparable, it calculates the prismatic prescription. When the results are not reliable, the algorithm advises of this and recommends more extensive and specific binocular assessments.

Hoya EyeGenius® considers prismatic values below 5.0 pdptr horizontally and below 3.0 pdptr vertically. Values greater than these are excluded, with the advice to carry out a more specific vision examination.

OUTPUT OF THE HOYA EYEGENIUS® METHOD

There are three possible outcomes to the Hoya EyeGenius® sequence:

1. All the measurements are found to be within the defined tolerance values.

   In this case, an aligning prism prescription is produced, and the examiner demonstrates the effect of the prescription on visual acuity and subjective comfort. The prism is prescribed in addition to the refraction values.

2. The measured values are smaller than 1.0 pdptr horizontally and/or 0.5 pdptr vertically.

   The prismatic prescription value is set to zero. If a zero prism is advised, refraction values will be prescribed.

   - One of the following occurs:
   - There is a large difference between FD far/near.
   - There are large absolute values outside of the range: aligning vertical prism is greater than 3 pdptr, and/or aligning horizontal prism greater than 5 pdptr).
   - The measurements and results are unreliable.

   In these cases, there is need for a more extensive binocular examination. Hoya EyeGenius® will recommend referral to a specialist, as it is likely that special care is required (e.g. vision therapy, different prisms for near/far or higher prism values).

CONCLUSION

Prismatic corrections are not the only method in the optician's toolbox, but they are an important addition to other instruments linked to issues such as refraction, accommodation and other visual functions. It can play an important role in helping patients achieve better vision and visual comfort.

Asthenopic complaints are astonishingly common: a study among opticians in Spain showed that, out of 1679 patients examined, 56.2% suffered from asthenopia (Montés-Micó, 2001). Given the number of people who predominantly work with computers, the total proportion of people with visual discomfort is estimated in the literature to be between

64 and 90% (Rosenfield, 2011). Many of these people are not aware that their issues can be traced back to their eyes, however (Yan *et al*., 2007). Asthenopia may thus not be considered as a serious problem by eye care professionals, despite the expected high potential in this field.

We hope that the efficiency and simplicity of the Hoya EyeGenius® method will increase interest in the field of binocular vision, and will be successfully implemented and used on daily basis in optometric practices and optical stores. However, it is important to remember that successful binocular correction requires that subjective refraction is taken care of first.

ACKNOWLEDGMENTS

The authors thank the Optician team including Chris Bennett and Bill Harvey for helping them with the publication of the article.

REFERENCES

Cooper, J. (1992). Clinical implications of vergence adaptation. *Optom. Vision Sci*., **69** (4), 300–307.

Duane, A. (1897). *A New Classification of the Motor Anomalies of the Eye: Based Upon Physiological Principles, Together With Their Symptoms, Diagnosis, and Treatment.* Vail, J. H., New York. 116 pp.

Günthert, K. (1980). Heterophorien im Spiegel der Statistik. *Der Augenoptiker*, **12**, 8–15.

Haase, H.-J. (1962). Binocular testing and distance correction with the Berlin Polatest (Translated by Baldwin W. R.). *J. Amer. Optom. Assoc*., **34**, 115–125.

Jenkins, T. C., Abd-Manan, F., Pardhan, S., Murgatroyd, R. N. (1994). Effect of fixation disparity on distance binocular visual acuity. *Ophthalm. Physiol. Optics*, **14** (2), 129–131.

Jenkins, T. C., Pickwell, L. D., Yekta, A. A. (1989). Criteria for decompensation in binocular vision. *Ophthalm. Physiol. Optics*, **9** (2), 121–125.

London, R., Crelier, R. S. (2006). Fixation disparity analysis: sensory and motor approaches. *Optometry*, **77** (12), 590–608.

Maddox, E. E. (1893). *The Clinical Use of Prisms; and the Decentering of Lenses, 2nd edition*. John Wright & Sons, Bristol, England. 170 pp.

Mallett, R. F. J. (1964). The investigation of heterophoria at near and a new fixation disparity technique. *The Optician*, **148** (3844/3845), 547–551, 574–581.

Methling, D., Jaschinski, W. (1996). Contrast sensitivity after wearing prisms to correct for heterophoria. *Ophthalm. Physiol. Optics*, **16** (3), 211–215.

Montés-Micó, R. (2001). Prevalence of general dysfunctions in binocular vision. *Ann. Ophthalm*., **33** (3), 205–208.

O'Leary, C. I., Evans, B. J. (2006). Double-masked randomised placebo-controlled trial of the effect of prismatic corrections on rate of reading and the relationship with symptoms. *Ophthalm. Physiol. Optics*, **26** (6), 555–565.

Rosenfield, M. (2011). Computer vision syndrome: a review of ocular causes and potential treatments. *Ophthalm. Physiol. Optics*, **31** (5), 502–515.

Schmitz, S. (1998). Kundenbefragung zur Mess- und Korrektionsmethodik nach H. J. Haase (MKH). *Deutsche Optikerzeitung*, (DOZ), **5**, 16–17.

Schroth, V. (1998). Erfolgsbeobachtung: Prismenkorrektion bei Kindern, die nicht freiwillig lesen. *Neues Optikerjournal,* (NOJ), **10**, 21–22.

Schroth, V., Joos, R., Jaschinski, W. (2015). Effects of prism eyeglasses on objective and subjective fixation disparity. *PLoS One*, **10** (10), e0138871.

Sheedy, J. E., Saladin, J. J. (1978). Association of symptoms with measures of oculomotor deficiencies. *Amer. J. Optom. Physiol. Optics*, **55** (10) 670–676.

Yan, Z., Hu, L., Chen, H., Lu, F. (2007). Computer Vision Syndrome: A widely spreading but largely unknown epidemic among computer users. *Comput. Hum. Behav*., **24** (5), 2026–2042.

HOYA EYEGENIUS®: JAUNA METODE FIKSĀCIJAS DISPARITĀTES MĒRĪŠANAI UN KORIĢĒŠANAI

Mūsdienu modernajā digitālajā vidē daudzi faktori ietekmē binokulārās redzes darbību: ilgas stundas, strādājot pie monitoriem, un skata virziena maiņa starp dažādām digitālajām iekārtām nelielos attālumos. Daudzi cilvēki var izjust ar redzi saistītas jeb astenopiskas sūdzības kā galvassāpes, acu nogurumu un dedzināšanu vai miglošanos. Šie simptomi var tikt mazināti, ja tiek izmantotas prizmas fiksācijas disparitātes koriģēšanai. Ir izveidota jauna, inovatīva metode fiksācijas disparitātes mērīšanai un koriģēšanai — *HOYA EyeGenius*®. *HOYA EyeGenius*® metode satur unikālu izmeklēšanas protokolu, pirms pārbaudes testus un tuvuma un tāluma fiksācijas disparitātes novērtēšanas testus. Pirms pārbaudes testi ļauj atlasīt pacientus ar astenopiskām sūdzībām un normālu binokulāro redzi un izslēgt pacientus ar anormālu binokulāro redzi. Galvenā *EyeGenius*® inovācija ir spēja noteikt koriģējošo prizmu apjomu, ņemot vērā nomērīto fiksācijas disparitātes apjomu. Tādēļ prizmas netiek izmantotas testa laikā. Digitālās ierīces izmantošana padara šo metodi interaktīvu un mazina redzes speciālista ietekmi.