Use of Liquid Trial Lens Technology in Standard Automated Perimetry

Application of a tunable trial lens in the HFA3 series of visual field analyzers

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Aim

With the ZEISS Humphrey® Field Analyzer 3 (HFA3™) 800 series, a new technology has been introduced to standard automated perimetry – the Liquid Trial Lens™. The goal of this adjustable lens is to streamline the workflow in automated perimetry. Instead of manually inserting trial lenses to compensate for refractive error and presbyopia, an automatic lens adjusts to each patient's predefined spherical refraction within seconds. In this paper, we discuss the working principle of the lens, how the Liquid Trial Lens compares to manual trial lenses, what percentage of the population can be examined with this lens, and finally, hints for efficient use of the device.

Methods

Studies were performed to evaluate the Liquid Trial Lens in comparison to manual trial lenses and specifically to quantify the effect of compensating for astigmatic refractive errors using the spherical equivalent. A literature search was done to estimate the percentage of patients who can be successfully tested with the automated lens. Furthermore we asked 19 validation sites who worked with the new HFA3 and its Liquid Trial Lens about their clinical experiences.

Summary of findings

Visual field tests taken with the Liquid Trial Lens and with manual trial lenses result in similar mean deviation (MD) values. The difference in MD between manual trial lenses and the Liquid Trial Lens was not statistically significant. Average difference was only -0.02dB +/-1.5dB (95%). Induced astigmatism up to 3 diopters, when compensated with the spherical equivalent correction, resulted in comparable MD values (difference less than 1dB). A literature search suggested that about 93% of the population can be tested within the refractive range of +/- 8 diopters. Feedback from the validation sites found that this new feature was considered good or very good by 95% of users. Technicians using the Liquid Trial Lens reported that the Liquid Trial Lens reduces test set up time and is very convenient.

Working Principle of the Liquid Trial Lens

The Liquid Trial Lens, a standard feature of the HFA3 Model 860, is an automated trial lens that allows the operator to preset and adjust the spherical refraction in 0.25 diopter steps from -8 to +8 diopters.

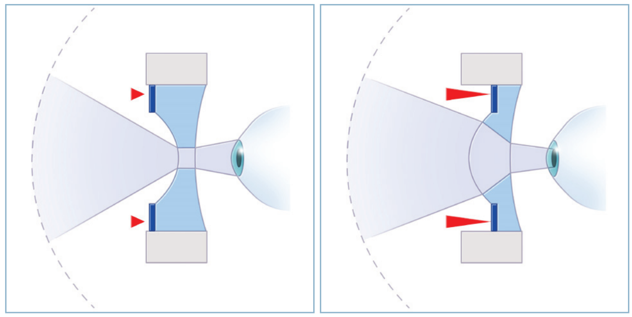


Image 1: The Liquid Trial Lens is filled with an optical liquid. When fluid pressure within the lens is gradually increased, the lens shape changes from concave to flat to convex. The fluid was chosen to be suitable for white light and colors. It withstands temperatures below -40°C without freezing and is therefore suitable for standard shipping with the instrument.

Refraction in Perimetry

Correcting refractive errors in visual fields is crucial for obtaining optimum perimetry test results. One diopter of spherical refractive blur in an undilated pupil will produce a little more than one decibel of depression of the hill of vision when testing with a Goldmann Size III stimulus.[i]

The HFA3's Liquid Trial Lens corrects only spherical refractive errors, and is not recommended for patients having large amount of astigmatism. Instead, such patients are tested using conventional trial lenses. In order to use the HFA3's Liquid Trial Lens for patients having mild amounts of astigmatic refractive error, we needed to quantify the effects of astigmatism on perimetry results. Callan et al recently studied this dependency and found that induced astigmatic blur of 1.5, 2.5, 3 and 3.5 diopters – compensated with the spherical equivalent of the astigmatism – resulted in average changes in perimetric sensitivity of -0.42 dB (SD 0.87), -0.58 dB (0.60), -0.77 dB (0.97) and -1.05 dB (0.95) respectively.[ii] It can therefore be expected that when using the Liquid Trial Lens in patients having up to 2 diopters of astigmatism the reduction in MD will average less than about half a dB, and less than about three quarters of a dB in patients having up to 3 diopters of astigmatism.

When using the Liquid Trial Lens, the HFA3 is programmed to calculate the spherical equivalent of each patient's astigmatic refractive error. On the basis of the above findings, we recommend use of the Liquid Trial Lens in patients having up to 2 diopters of astigmatism and to use conventional trial lenses in patients having more than 2 diopters of astigmatism. A more aggressive approach would be to switch to manual trial lenses only for patients having more than 3 diopters of astigmatism. In any case, the most important principle is to be consistent from test to test.

In what percentage of patients can the Liquid Trial Lens replace manual trial lenses?

The Liquid Trial Lens covers a spherical range of +/- 8 diopters. For prescriptions outside this range or for the application of large astigmatic corrections, the Liquid Trial Lens can easily be replaced by a manual trial lens holder.

Reports on the prevalence of refractive error in the human population suggest that the Liquid Trial Lens can be used in over 90% of patients. One study found that 1.2% of the population have hyperopia beyond 4 diopters and 2.3% of population who have myopia worse than -6 diopters.[iii] The Tajimi Eye Study from Japan reported 5.5% patients with Myopia worse than -6 diopters.[iv] Most of these patients beyond -6 diopters can still be examined with the Liquid Trial Lens as the range for presbyopic patients can address myopia of as much as -11.25 diopters. The limits of +4 and -6 diopters are the most extreme refractions for which we found population based statistics in a literature search. According to a study on a Chinese population 3.75% of eyes had astigmatism of 3.01 diopters or more.[v]

Application hints for the Liquid Trial Lens

The 19 sites that tested the HFA3 before its commercial release reported that they used the Liquid Trial Lens almost exclusively for testing their patients. The Liquid Trial Lens' major advantage was reported to be time savings. In only a few cases, the use of the Liquid Trial Lens resulted in lens rim artifacts. In response to these cases and in collaboration with the validation sites we developed the suggestions that are printed later in this section. Internal design documents show that the usable visual angles at various vertex distances do not significantly differ between the Liquid Trial Lens and an equivalent manual trial lens.[vi,vii] Table 1 is an example of a typical setting with +2.5 diopters of refraction, vertex distances of 10, 13 and 18mm and vertical displacements of 0 and 3 millimeters from the center of the lens. In order to have identical refractive conditions, only a single lens was inserted in the manual trial lens holder. Since the manual trial lens holder limits the field of view in the inferior visual field, and the superior visual field is only limited by the rim of the lens, the findings for the manual trial lens holder are asymmetric while the findings for the Liquid Trial Lens are symmetric.

Image 2: The Liquid Trial Lens in comparison to the manual trial lens holder. The aperture of the Liquid Trial Lens on the front side is approximately 28 mm and 34 mm on the back side. The manual trial lens holder has an aperture at the front and the back of 34 mm. In both lens systems, it is the back aperture that limits the field of view..

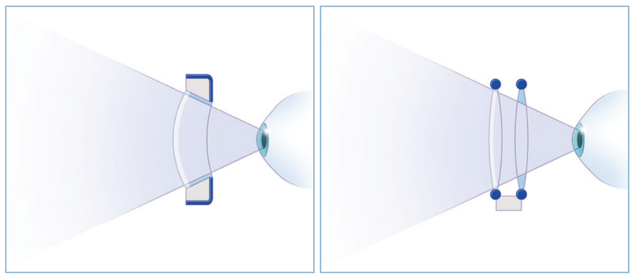


Image 3: Vertex distance and the lateral tolerance of the Liquid Trial Lens compared to a manual trial lens holder with sphere and cylinder lens have shown to be similar as they are mainly influenced by the back aperture, oriented towards the bowl of the visual field analyzer.

From these calculations, we conclude that, for both lens systems, even small deviations from the ideal eye position can lead to lens rim artifacts, especially if the vertex distance is more than 10 mm. Up to 13 mm vertex distance, the minimum viewing angles of the Liquid Trial Lens are superior to the respective viewing angles of a single manual trial lens. At vertex distances of 18 mm and more, both refractive solutions will potentially produce lens rim artifacts, even if constant and precise lateral adjustments are made to keep the pupil centered.

HFA3 models that have gaze tracking also are equipped with Head Tracking. The goal of Head Tracking is to minimize the presence of trial lens artifacts by automatically keeping the eye centered. Whenever the patient shifts position, the Head

Tracker gently and gradually moves the chin rest to re-center eye behind the lens. Head Tracking works both with the Liquid Trial Lens and when manual trial lenses are used.

Because large vertex distances are associated with trial lens artifacts, we recommend keeping the vertex distance at about 10mm, whether using the Liquid Trial Lens or conventional trial lenses. For most patients, we advise placing the trial lens so that it lightly touches the brow, as long as doing so does not cause the lashes to touch the lens surface.[viii] In most of the cases where lens rim artifacts have been observed, the recommended vertex distance was exceeded and measured in the range of 15 to 20 mm at the end of the test.

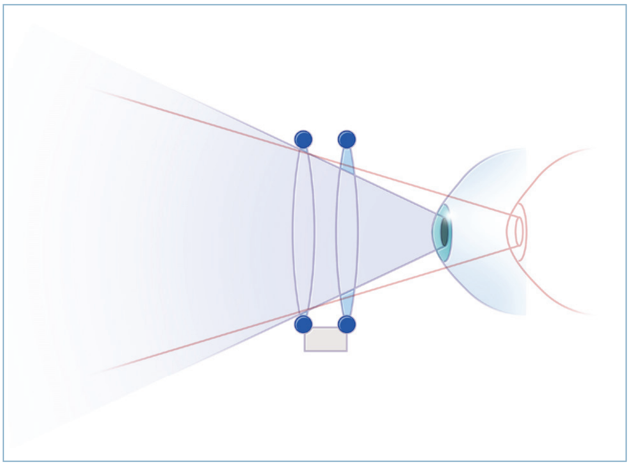
Liquid Trial Lens™

Vertex / Vertical decentration	0 mm	3 mm
10 mm	74 °	63 °
13 mm	66 °	54 °
18 mm	55 °	43 °

Manual Trial Lens

Vertex / Vertical decentration	0 mm	3 mm
10 mm	68°	58 °
13 mm	62 °	52 °
18 mm	53 °	45 °

Table 1: Comparison of fields of view in degrees for a 4.5 mm pupil at +2.5 diopters of refraction, comparing the Liquid Trial Lens with a manual trial lens holder using a single trial lens. Note that for both the Liquid Trial Lens and for manual trial lenses, already at a vertex distance of 13 mm, a vertical deviation of 3 mm downward from the lens center would lead to potential lens rim artifacts both in the 30-2 test (required viewing angle 58°) and in the nasal step area of the 24-2 test (required viewing angle 55°). The color codes refer to the likelihood that lens rim artifacts are present when performing a 24-2 test.



The figure above illustrates the change in unobstructed visual angle resulting from a change in vertex distance.

How comparable are test results performed with the Liquid Trial Lens versus with the manual trial lens holder?

We investigated the comparability of visual field test results using the Liquid Trial Lens versus a manual lens holder with thin rimmed trial lenses to compensate for refractive errors.[ix] Sixteen eyes of 11 patients were tested using either the 30-2 or 24-2 test pattern and the SITA Standard test strategy. Subject age ranged from 38 to 66 years. When using manual trial lenses, cylinders up to 1.25 diopters were compensated with the spherical equivalent. The difference in Mean Deviation (MD) and the 95% confidence interval was -0.02dB (+/- 1.5dB) between the manual trial lens MD and the Liquid Trial Lens and thus not statistically significant.

Reinventing patient refraction in visual fields

When running follow-up examinations, the HFA3 is programmed to use the same refractive correction as was used in the most recent prior test, and to automatically set the Liquid Trial Lens to the age-appropriate presbyopic correction. The user has the option of entering new refractive data and/or changing the refractive correction at any time. The user interface contains "+" and "–" buttons that are available to change the Liquid Trial Lens power in 0.25 diopter steps. This is especially useful if the patient perceives the fixation target as blurred. In these cases, there is a considerable gain in time and patient comfort due to the fact that the patient can stay seated and no refractive lenses need to be exchanged.

We hope that this simpler and a more straight forward procedure for adjusting the refractive correction will contribute to a shift in the practice patterns of visual field testing. Technicians may incorporate easy adjustment of the Liquid Trial Lens to the patient's optimal refractive correction into their workflow.

In conclusion

We believe that the Liquid Trial Lens will significantly decrease the need to use conventional trial lenses, shorten test set-up time, and increase clinical efficiency. Further studies on this topic are desirable and expected, as the Liquid Trial Lens is very new technology. Early user feedback suggests that users will seldom need to switch back to manual trial lenses.

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