Vertex distance variability of the Vision-S™ 700 refractors in normal population

Variabilidade da distância vértice do refrator Vision-S™ 700 em uma população normal

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ABSTRACT

Objective: To study vertex-optical distance variation and estimate its impact on manifest refraction.

Methods: Prospective study in a private clinic using the Vision-S™ 700 with five forehead positions. Forehead on the third position showed the closest vertex-optical distance of 12mm.

Results: Analysis of 52 eyes from 26 patients revealed mean differences in vertex-optical distance of 12.25mm (right eye) and 11.75mm (left eye). A 2mm change in vertex-optical distance resulted in a 0.05D change for a 5D spherical equivalent and 0.20D for a 10D equivalent.

Conclusion: Vertex-optical distance varies among patients and is influenced by forehead adjustment. These variations impact refraction accuracy and treatment evaluation. Adjusting the forehead to the third position on the Vision-S™ 700 is recommended.

RESUMO

Objetivo: Estudar a variação da distância vértice-óptico, de acordo com o ajuste da testa, e estimar seu impacto na refração manifesta.

Métodos: Estudo prospectivo realizado em clínica privada. A refração foi realizada utilizando cinco posições preestabelecidas com o Vision-Sa 700. A testa disposta na terceira posição apresentou distância vértice do refrator mais próxima de 12mm.

Resultados: Foram analisados 52 olhos de 26 pacientes. A diferença média da distância vértice do refrator no olho direito foi de 12,25mm (variação de 11,50mm) e, no olho esquerdo, 11,75mm (variação de 12,00mm). O impacto foi de 2mm na distância vértice do refrator, fomentando em uma mudança de 0,05D para um equivalente esférico de 5D e 0,20D para um equivalente de 10D.

Conclusão: A distância vértice do refrator varia entre pacientes, estando relacionada ao ajuste da testa. As variações afetam a precisão da refração, impactando no ajuste dos óculos, das lentes de contato e na avaliação pós-operatória de cirurgia refrativa. Sugerimos ajustar a posição da testa para terceira posição no Vision-S™ 700, se a distância vértice do refrator não for medida em todos os pacientes.

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INTRODUCTION

The back vertex distance (BVD) is an essential but usually neglected characteristic of the clinical refraction exam. Methods have developed significantly in measuring and delivering clinical and surgical treatments for refractive errors. Ophthalmologists and other practitioners want to provide their patients with the best possible vision correction so that BVD's impact is a future consideration. Back vertex distance is the distance between the eye and its corrective lens. It is measured from the corneal surface to the back of the lens.[1-5]

The formula to calculate BVD over the refraction is:

De = Dl / 1+ (d x Dl) Equation 1

- De is the diopter power being perceived by the wearer.
- Dl is the actual diopter power of the lens.
- d is the distance in meters of BVD.

The comprehension of the above formula creates the rules below on the minus lens. It gains perceived power when it moves towards the eye. It loses perceived power when it moves away from the eye. The comprehension of the above formula creates the rules below on the plus lens. It loses perceived power when it moves toward the eye. It gains perceived power when it moves away from the eye.

The commonly accepted convention that BVD is almost always equal to 12mm is blocking refraction improvements. Two old references support this misunderstanding. The first one is the manual "Distometer: Instructions for Use (Distributed by Haag-Streit Service. Waldwick, New Jersey) that states, "Clinical experience has established that the spectacle lenses, when fitted properly, are placed on average 8 to 12mm from the cornea". Another source of this old convention is the Reichert Ultramatic RX Master Phoropter instruction manual.

Back vertex distance is a critical part of ophthalmic optics, but it has been overlooked by the ancient application of "industry averages" in the optical industry. The optic industry widely spread the BVD measurement calculations between the 1940s and 1970s of the 20th century due to the high number of aphakes (cataract surgery patients did not receive an intraocular lens implant).[(6)] Aphakes eyeglass prescriptions easily reach +20.00D or beyond. These powers made BVD vital for refraction. Even the slightest difference between refracted distances would make a dramatic difference for the patient. Therefore, knowing how to compensate for BVD in such patients is imperative.

Back vertex distance is equal to 0.000 meters on the contact lens. The importance of Back vertex distance is also well known by workers who routinely prescribe contact lenses and eyeglasses to high myopic and hypermetric patients (higher than 4,00 diopters). In addition, the BVD adjustment is commonly applied when calculating the power of a soft or rigid contact lens, given the spectacle lens prescription.

Prescription lenses in eyeglass frames have different effective powers at different distances, tilts, and wrap angles from the eye. Telling a progressive or bifocal wearer to slide their glasses away from the eyes provides a more robust addition and increases patient near vision quality. For example, in positive lenses, the farther the BDV is from the eye, the more efficient the lens will be. In negative lenses, the farther the BDV is from the eye, the more inefficient it will be. Thus, if we have a lens of -4.00 spherical diopters with a BVD less than 12mm away (the standard BVD distance used in the prescription by ophthalmologists), we will be hypercorrecting the patient.

Clinically, BVD ranges from 8 to 30mm. Therefore, assuming that the BVD is 12mm for all patients during refraction, it usually generates a refractive error.

Some of the methods and instruments used to measure BVD are cited below:

- BVD rule.
- The pupilometer.
- The pupillary distance (PD) rule practice (most widely used).
- The distometer.
- Split prism ruler.
- Digital instruments.[(7)]
- Direct sighting and through 90° mirrors located at the side of the refractor along with correction factor tables.

BVD was not considered vital until now for several reasons, including the non-factoring in the BVD for ophthalmic lenses in 0.25D increments, which traditionally has had limited effects; and the non-factoring in the BVD that has never been particularly problematic for a range of corrections from -4.00 to +4.00D in 0.25D increments. High myopia and hyperopia patients are an exception, as a variation of 5mm (±2.5mm) with a power of 5.00D can induce a variation of 0.125D. This modification is necessary to adjust the correction by an increment of 0.25D.

BVD should be incorporated because:

- Nowadays, lenses are available in 0.01 D increments. Therefore, BVD matters even for low corrections, enhancing refraction accuracy.
- Subjection refraction has low accuracy.[(8)]
- Potentially, time, and money-saving.

- The advent and growth of “as-worn” progressive and single-vision lenses.
- An incredible increase in high myopia will reach more than 50% of the Earth’s population by 2050.[9]
- More precise values of BVD enhance the accuracy of refractive procedures like laser vision correction (LVC), posterior chamber phakic intraocular lens (pIOL), corneal inlays, cataract surgery, and contact lens prescription.
- In the case of distance vision, the effect of BVD is one of the essential factors in final refractive errors. It also influences prismatic outcomes and decentration[10] upon residual astigmatism in intraocular lenses (IOL)[11] and aspheric concave ophthalmic lenses.[12]
- The measurement of BVD can help staff select appropriate frames before ordering lenses. It helps to create high-quality eyeglasses and saves ophthalmologists’ business time and money in terms of unscheduled and no-charge return office visits to handle patient complaints.

Assuming a BVD of 12mm for every patient will result in refractive errors in many patients. However, the assumption that 12mm is good enough is like saying that 22,00 diopters is the average lens power for cataract surgery and is suitable for all cataract patients, as veterinarians do in vet cataract surgery.

Considering that variations in vertex distance of the refractor compromise the accuracy of refraction, as well as affecting the adjustment of glasses, contact lenses, and post-operative evaluation in refractive surgery, this study aimed to investigate these variations according to brow adjustment and estimate their impact on manifest refraction, aiming to ensure success in patient procedures.

OBJECTIVE

To study vertex-optical distance variation and estimate its impact on manifest refraction.

METHODS

Using Essilor phoropter Vision-S™ 700, a trained ophthalmologist measured the BVD in five preestablished forehead adjustments of 27 consecutive patients presenting for routine refraction at a private clinic in Brazil. The population sample consisted of 10 men and 17 women. The youngest participant was 13 years old, and the oldest was 57. All 27 participants agreed to participate in this study, which met the Helsinki criteria.

It was noticed that the knob that performed the forehead adjustment made four complete turns from the minimum adjustment to the maximum forehead adjustment. This circular knob looks like a clock and is divided into 12 fractions. This button rotates around its axis (Figure 1). The distance between the patient’s forehead and the equipment increases proportionally as the knob is turned clockwise. The BVD also increases as the length from the forehead to the equipment increases. Forehead adjustment one was set at the minimum forehead adjustment where the head was at the closest distance to the equipment. Forehead adjustment two was established by turning the knob once around its axis. Forehead adjustment three was reached by rotating the knob twice around its axis. Forehead adjustment four was based on rotating the knob three times around its axis. Forehead adjustment five was established by turning the knob four times around its axis, and it also coincides with the maximum head distance from the phoropter.

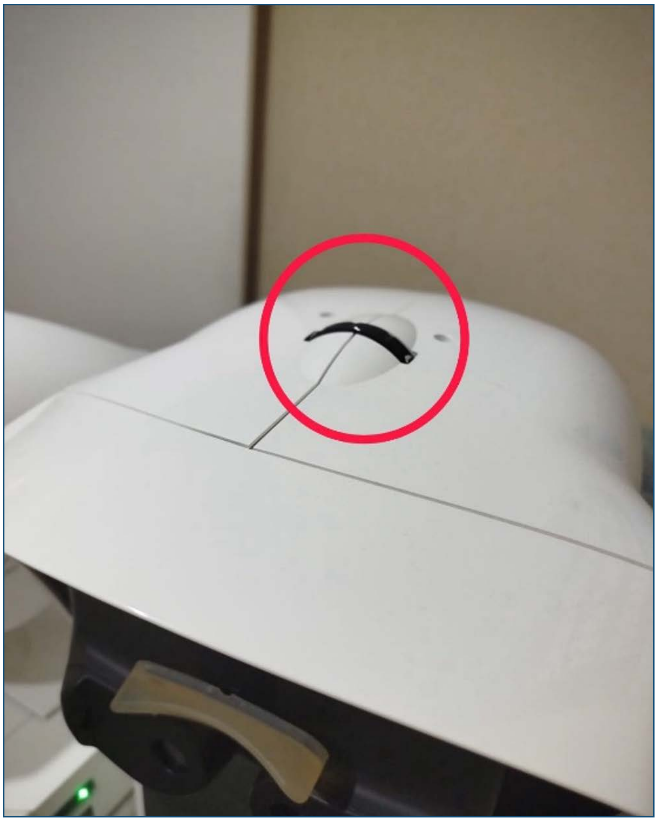

Figure 1. Vertex distance adjustment Knob of Essilor phoropter Vision-S™ 700.

Back vertex distance measurements were performed using a system of video cameras designed to determine accurate measurements of BVD in five preestablished forehead adjustments for each patient. In addition, the eye-to-phoropter distance was randomly measured in a sample of 27 patients on one day.

Each measurement was taken as follows: the patient was placed behind the phoropter head, their gaze directed in the primary position, and they were asked to look at a chart screen located 5m away (Figure 2).

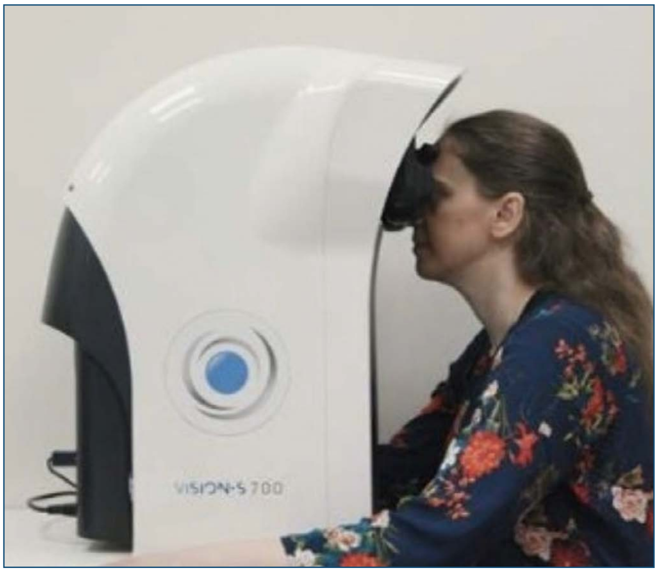

Figure 2. Adequate body position on Essilor phoropter Vision-S™ 700.

The phoropter's interpupillary distance was adjusted for each eye. Using video cameras located behind each of the phoropter's half-heads, photos of the right and left eyes were taken laterally and appeared on the phoropter's control panel. The virtual reticle could then be adjusted and positioned in correspondence with the apex of each cornea. The adjustments were made binocularly; if a difference was found between the left and right eyes, they were made monocularly. The system then accurately indicated the value of the eye-to-phoropter distance in 0.5mm increments. For each patient, the measurement was taken once in five established adjustments, with the patients being asked to move back from the phoropter and reposition themselves.

In addition, twenty-five measurements were repeated on a patient of reference, asking him to move his head back from the phoropter after each measure and reposition himself for each new measurement.

RESULTS

The data is within the expected statistical normality. They show that in established forehead adjustment one, the right eye BVD varied by 7.50mm (from 5.5mm for the smallest to 13.0mm for the largest), with an average established at 7.00mm with a standard deviation of ±2,08mm in minimum forehead adjustment. In the left eye, BVD varied by 7.50mm (from 5.5mm for the smallest to 13.0mm for the largest), with an average established at 7.63mm with a standard deviation of ±1.85mm in forehead adjustment one (minimum set forehead adjustment).

BVD in established forehead adjustment two varied by 8.50mm (from 7.0mm for the smallest to 15.5mm for the largest), with an average of 8.75mm with a standard deviation of ±2.36mm. In the left eye, BVD varied by 9.50mm (from 6.0mm for the smallest to 15.50mm for the largest), with an average established at 8.50mm with a standard deviation of ±2.46mm in forehead adjustment two.

Back vertex distance in established forehead adjustment three varied by 11.50mm (from 8.00mm for the smallest to 19.50mm for the largest), with an average of 12.25mm with a standard deviation of ±3.11mm. In the left eye, BVD varied by 10.50mm (from 7.5mm for the smallest to 18.0mm for the largest), with an average established at 11.75mm with a standard deviation of ±3.23mm in the forehead adjustment three.

Back vertex distance in the established forehead adjustment four varied by 15.50mm (from 8.00mm for the smallest to 23.5mm for the largest), with an average of 15.11mm with a standard deviation of ±3.84mm. In the left eye, BVD varied by 13.00mm (from 8.5mm for the smallest to 21.50mm for the largest), with an average established at 14.61mm with a standard deviation of ±3.72mm in the forehead adjustment four.

Back vertex distance in the forehead adjustment five (maximum established forehead adjustment) varied by 15.00mm (from 12.50mm for the smallest to 27.5mm for the largest), with an average of 18.41mm with a standard deviation of ±4.29mm. In the left eye, BVD varied by 17.00mm (from 10.5mm for the smallest to 27.5mm for the largest), with an average established at 17.98mm with a standard deviation of ±4.38mm in the forehead adjustment four (maximum set forehead adjustment). On the other hand, the measurements repeated five times on one patient show a maximum range of variation of 3.00mm with a standard deviation of ±1.50mm.

DISCUSSION

Back vertex distance depends on the morphology of a patient's head, the patient's position behind the phoropter, and the phoropter forehead adjustment. Therefore, such an often-neglected parameter of eye-to-phoropter distance must be considered when calculating the refraction correction.

Clinically, the study's BVD ranges from 5.50mm to 27.50mm according to forehead adjustment. Assuming that the BVD is 12 for all patients during refraction frequently generates a refractive error. Dogmatically, BVD is equal to 12mm. The non-measurement of BDV is one of the missing values that may improve refraction. Back vertex distance has potential applications in different areas of vision-study, like intraocular and extraocular surgical visual corrections, contact lenses, and eyeglass prescriptions. For example, using an average 12mm BVD of 35mm will result in considerable inaccuracies, overcorrecting -15.00 D by 2.87 D.[13]

Digital instruments are a money and time-saving method. Creating a BVD measurement as a routine may save time and money, decreasing unscheduled and no-charge return office visits as fewer patients return unsatisfied with their refraction. The practice will also cut down on material costs incurred by the operation.

Many modern excimer laser systems' software versions do not allow entry of BVD greater than 25mm. The inaccuracy of BVD measurements at the phoropter may explain some of the unpredictability of refractive outcomes in previously reported studies.

Neglecting BVD is often a significant cause of incorrect power calculations with excimer laser treatments and phakic IOLs. Most phoropters specify a BVD between 12.00mm and 13.75mm. However, even when the eye is adequately aligned, BVD can vary significantly because different lenses are used in the phoropter to get a specific power.[14]

Performing over-refraction with a soft contact lens and employing formulas incorporating BVD may reduce incorrect power calculation rates, as Dr. Holladay described in the American Journal of Ophthalmology in 1993.[15]

The wide range of BVD values found in our study reinforces the importance of BVD for clinical refraction. Anatomic variations, no uniformity in the starting position of the refractor headrest among different examiners, and differences in baseline phoropter headrest position and posture may explain the BVD measurement (Figures 3-4).[13]

Eye-to-phoropter distance is often adjusted when the phoropter is positioned in front of the patient's head. First, the phoropter must be placed close to the patient's eyes to have as wide a field of vision as possible, but not so close that their eyelashes touch the phoropter's back window (which is not only unpleasant for the patient but can make the phoropter dirty).

With traditional phoropters, this adjustment is achieved by adjusting the forehead rest, paying close attention to the patient's eyes, either from behind the phoropter or through the phoropter, using a specially designed system of graduated lateral mirrors.

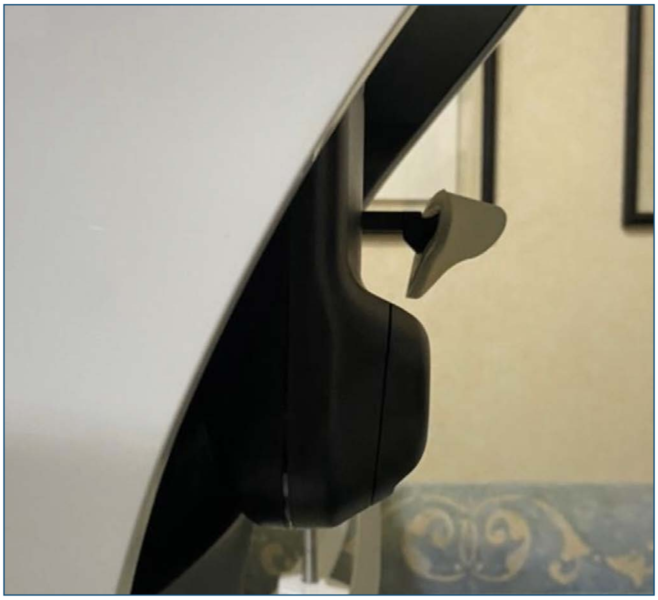

Figure 3. Maximum forehead adjustment on Essilor phoropter Vision-S™ 700.

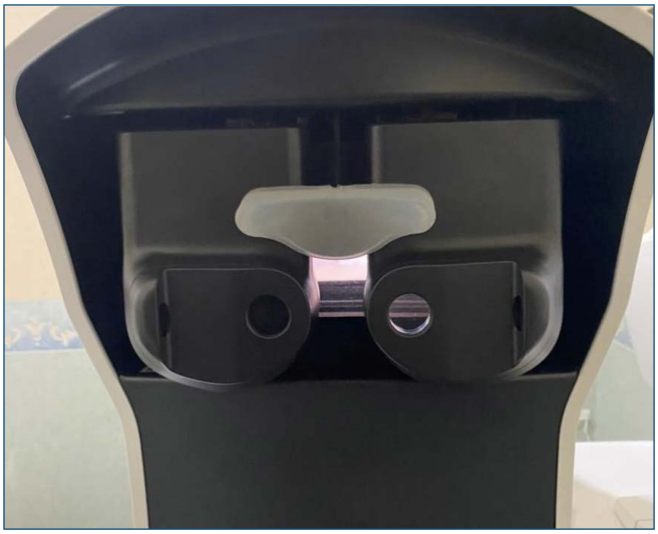

Figure 4. Front view of Essilor Phoropter Vision-S™ 700.

Several aspects related to eye-to-phoropter distance must be noted. It can vary considerably from one patient to another with the same forehead rest position (as we have shown). The phoropter head is carefully adjusted in front of the patient's eyes.

The patient's head position also influences this distance: it is reduced if the patient lifts their head and increases if they lower it. Hence, the patient needs to be in a comfortable enough position that they will not tend to change it during the refraction.

The distance can change throughout the refraction, so it is essential to check it at the end of the examination, particularly for factual corrections and the prescribing of objective lenses, in 0.01D increments.

Using new current phoropters like Essilor Vision-S™ 700, we can precisely measure the distance using video cameras and adjust it with great precision so that it can be factored into the calculation of a lens correction.

Although it is essential to accurately determine the eye-to-phoropter distance, knowing this distance will matter little if you cannot also measure the distance between the eye and the eyeglass frames. Opticians have various systems that allow them to count this. Some manual measurement devices were sometimes used in the past, but today more than ever, these measurements are performed with computers and electronic tablets.

It is possible to measure eye-to-phoropter quickly and accurately during the refraction examination. The value of the prescription must be converted to the standard reference distance of 12mm at the end of the investigation. The new phoropters like Essilor Vision-S™ 700 generate automatic calculation, making this process easier.

The frames have been selected, but before lenses are ordered, the optician must measure the eye-to-frame distance and provide this data to the manufacturer when ordering the lenses.

The manufacturer must convert the value of the optical correction, considered to be established for 12mm, to the eye-to-frame distance measured by the optician just before the lenses are manufactured.

If the above sequential actions were taken, it would be possible to provide patients with a highly accurate correction of their ametropia. Another scientifically supported tool to reduce refractive surprises is to perform over-refraction with a soft contact lens.

Using a standard protocol for refraction measurement in a very controlled setting enables the repeatability of refraction performed by different examiners.[16] Mackensie proved that refractions performed by multiple optometrists on a single eye would differ in their stigmatic component by over 0.78 D on average, not more than once in 20 refractions.[8] Whereas a single optometrist can perform refraction with the precision of ±0.25D, refractions performed by different optometrists may differ in their astigmatic component by 0.75D or more. Due to factors like this one mentioned by Mackensie, we must provide as much data as possible to have a precise refraction.[8]

CONCLUSION

Our study aimed to enhance understanding of vertex-optical distance variation and its implications for manifest refraction, employing the Vision 700 with five forehead positions. We endeavored to precisely measure refractor BVD and observed a significant dependence on forehead adjustments. These variations markedly influenced refraction accuracy and treatment assessment, highlighting the imperative of integrating BVD into procedures. This significance is underscored by the refinement in modern lenses, available in increments as precise as 0.01 D, wherein BVD plays a critical role even in minor corrections. The Essilor phoropter Vision-Sä 700 introduces an innovative method of indirectly ascertaining BVD through its lateral cameras, ensuring precision, speed, and reliability. Accurate measurement of BVD and subsequent calculation of adjusted power are indispensable facets of an optician's practice. Neglecting BVD, particularly in high diopters, risks furnishing clients with spectacles deviating substantially from their precise prescriptions, leading to compromised visual acuity. While our study represents an initial exploration in this realm, it underscores the imperative for further research. Randomized studies involving larger patient cohorts are essential to validate and expand upon our findings, ensuring robust evidence to guide clinical practice. In conclusion, our study elucidates the pivotal role of BVD in manifest refraction, advocating for its integration into standard procedures to optimize visual correction outcomes.

CLINICAL EXAMPLE

ABC, a high presbyope patient, complains that he has trouble reading with his new prescription. However, the staff has checked and rechecked the glasses (pupillary measurements, segment height, lens power, and the adjustment), but he still complains that he must hold reading materials very close to see them. His new prescription differs slightly from the old one, and the base curve is the same.

The often-ignored calculation of BVD is the likely culprit. The BVD influences the perceived power of the lens. It is even more critical in higher power lenses: spherical ±5.00D or more. In such lenses, there can be significant differences in power if the BVD of those new lenses differs from the testing BVD used during the refraction.

AUTHORS' CONTRIBUTION

All authors made substantial contributions to the conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and state to be accountable for all aspects of the work.

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