Original scientific paper

The Importance of the Relationship Between The Position of the Correcting Lens Principal Planes (H'1-H'2) and Principal Planes (H1-H2) of the Optical Eye System – Aphakic Correction

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A B S T R A C T

In the clinical refraction of the eye, aniseikonia and anisometropia are inevitably used terms. Image formation and its retinal size is the function of the power of the dioptric eye system. However, the correcting lens in front of the eye and the eye optical system represent a unique optical afocal system, in which the distance between correcting lens and corneal vertex is of utmost importance, since it determines the size (together with appropriate correcting lens) of the retinal image. In the case of a monoculus, the size of the retinal image is not important. But, when correcting one eye while the other is emmetropic, it is important to correct it in the way that the image of the corrected eye does not produce considerable aniseikonia as a consequence of anisometropia. The authors hereby present mathematical calculation proving that if the principal point of the correcting lens P'2 is in the F1 of the emmetropic eye, meaning that? is equal to the front focal length of the emmetropic eye, there is no change in the refractive eye system, i.e. it becomes emmetropic and there is no change in the size of the retinal image. It means that an ideal position of the correcting lens in front of the eye guarantees no aniseikonia even in the extreme case of monocular aphakic spectacle correction.

***Key words**: aniseikonia, ametropia, lens correction of ametropia, aphakia*

Introduction

Spectacle lens correction of ametropic eye is troublesome for several reasons[1–3]. The basic aspect and condition is to render emmetropic an ametropic eye. Generally, that is not a problem, except in the case of complicated refraction associated with various forms of astigmatism[4,5]. However, the aniseikonia problem appears frequently with anisometropia, especially in cases of major refractive differences between the two eyes[1,2]. Such cases are best solved, if possible, with contact lenses. The contact lens lies on the anterior corneal surface and theoretically speaking, the distance between T of the contact lens and H1 of the emmetropic eye = 1.35–1.46 mm, but the contact lens and the cornea represent a unique polyachromatic optical system so there is no effect of aniseikonia.

Patients and Methods

Our aim was to express, from geometrical point of view, when and of what amount anisometropia in the cases of extreme anisometropias will appear.

By calculating the magnification using this formula, for RD = –1.0 D, it comes out that Y of the retinal image is reduced by 2% (1–0.98 × 1000 0.2%).

$$Y = 1 + 0.0171\ (-1) = 0.983$$

Formula for:

$$Y = 1/1 - \Delta \times DKL \quad DKL = \text{correcting lens dioptry}$$

$$Y = 1/\ 1 - 1/D \times DKL \quad \Delta = f1 = 1/D$$

$$Y = 1/1 = 1$$

Respecting the above mentioned conditions, there will be no change in the retinal image size, even in the case of monocular aphakia, when comparing the two eyes.

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When we substitute the conventional value d/n with the value $\Delta = e$ in the classic Gullstrand formula[6,7]:

$$F(D) = D1 + D2 - \Delta \times D1 \times D2$$

$$F(D) = 10.0\ \text{Dptr} + 58.64\ \text{Dptr} - 1/D2 \times 10.0\ \text{Dptr} \times 58.64\ \text{Dptr}$$

$$F(D) = 58.64\ \text{Dptr} = D2,\ f1 = 17.06\ \text{mm}$$

D1 = 10.0 Dptr aphakia

D2 = 58.64 emmetropic eye power

F(D) = spectacle corrected aphakic eye optical power

It is important to remark that we achieved satisfactory state without aniseiconia in three elderly patients with monocular aphakia and other eye ofvision, V= 0.6–0.8.

Discussion and Conclusion

We are aware that this paper has little practical value since no one is going to correct monocular aphakic patients in this way. But, from theoretical point of view[6,7], it is important to understand the importance of geometrical optics rules, in general and not only for the eye, i.e. the importance of principal points of optical spherical systems: the focal points of the object and of the image F1 and F2, the nodal points N1 and N2, as well as principal planes points. This mathematical calculation is applicable in centered spherical systems, which eye is not entirely. It is important to mention conjugate planes as well, which represent the basis for geometrical optics calculation platform. Practical conclusion and implementation of this calculation is to emphasise the importance of respecting vertex values T1-T2 as an imperative in spectacle prescription and fabrication.

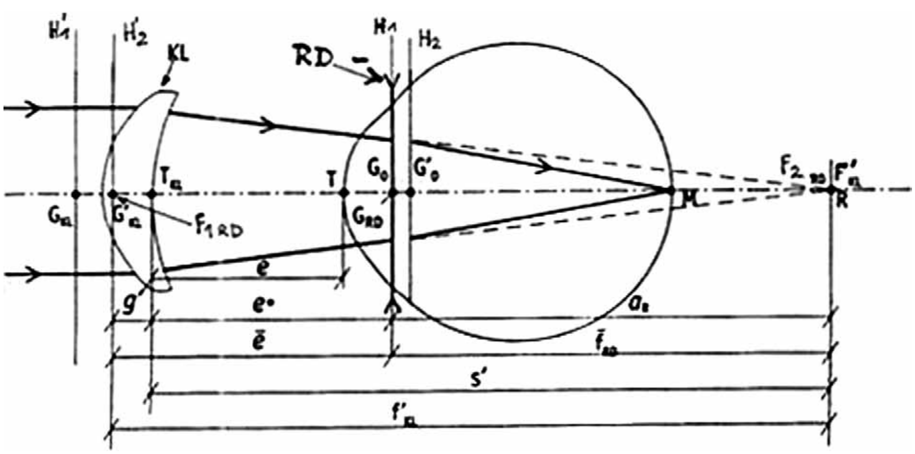

Fig. 1. represents one of the conditions of the correcting lens position KL(D1) in front of the aphakic eye with refraction deficit – RD, so that the focus of the emmetropic eye – F1RD is in the focus of the correcting lens F'KL[1]. Y (magnification) = 1+ Δ × RD.

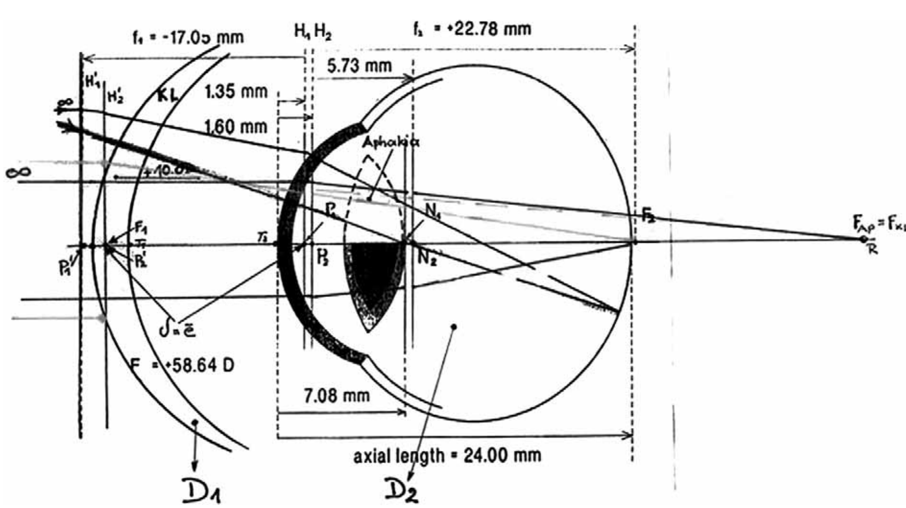

Fig. 2. shows the case of aphakic eye corrected with +10.0 D spectacle lens, which meets the requirement that the focal length of the aphakic eye (FAP) is in the focal point of the correcting lens (FKL). Besides, one more condition is fulfilled; F1 – principal point of the front focal length – F1 of the emmetropic eye is in the principal point P2 of the principal plane of the correcting lens image H'2. It means that Y equals to F1[4,5].

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ZNAČAJ ODNOSA POZICIJE GLAVNIH RAVNINA KOREKCIONE LEĆE (H'1-H'2) I GLAVNIH RAVNINA (H1-H2) OPTIČKOG SUSTAVA OKA-KOREKCIJA AFAKIJE

SAŽETAK

U kliničkoj refrakciji oka nužno se barata sa terminima anizeikonije i anizometropije. Izračunom stvaranja slike i njene veličine na retini, zaključuje se da je ona funkcija jačine dioptrijskog sustava oka. No međutim, korekciona leća ispred oka predstavlja, sa optičkim sustavom oka, jedan optički afokalni sustav, u kojem je vrlo bitna udaljenost korekcione leće od tjemena rožnice, jer o toj veličini, pored adekvatne korekcijske leće, ovisi veličina sličice na retini. Autori matematski izlažu, u geometrijskoj optici oka, sa dokazom, da kada se glavna točka slike korekcione leće P'2 nalazi u F1 emetropnog oka – equivalent power focal length (no front vertex focal length), tada nema promjene refrakcijskog sustava oka, tj. ono se emetropizira, pa nema ne promjene veličine sličice na retini. Pod idealnim uvjetima, pozicije korekcione leće ispred oka, nema pojave anizeikonije ni u slučaju korekcije monokularne afakije. Shvatljivo je, da se u praksi ovo ne promjenjuje, premda su autori u nekoliko slučajeva imali zadovoljavajuću korekciju afakije bez anizeikonije.