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Optical Coherence Tomography in the Prone Position: A Novel Approach for Glaucoma Assessment

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Abstract

Glaucoma is characterized by a progressive loss of ganglion cells and of the retinal nerve fiber layer (RNFL), mostly related to an intraocular pressure higher than normal. According to the format of the camerular sinus, Glaucoma is divided in Open-Angle and Angle-Closure. Classically, it is known that angle-closure glaucoma is more aggressive than Open-angle Glaucoma for reaching extremely high intraocular pressure levels.

The technique that we created is an improvement of the technique idealized and knew as a prone position provocative test for angle-closure glaucoma. As OCT did not exist at that time, the identification of the patient with angle-closure glaucoma was done by comparing the IOP measurements before and after a time with the patient in prone position.

The objective of this study is to present a new diagnostic approach using an existing technology: the optical coherence tomography (OCT). The innovation lies in how to use the OCT device. We have developed a theoretical system of identification of the camerular sinus type which can improve the diagnosis of angle-closure glaucoma. The improved system for optic coherence tomography, object of this article, consists of an apparatus for performing OCT examination of the anterior segment in the lying position.

Keywords: Optic coherence tomography; Glaucoma; Intraocular pressure

Introduction

Glaucoma is characterized by a progressive loss of ganglion cells and of the retinal nerve fiber layer (RNFL), mostly related to an intraocular pressure higher than normal [1,2]. Ue vascular theory of pathophysiology of Glaucoma shows us that there is some difficulty in nourishing the optic nerve head with blood when the intraocular pressure is higher than the arterial pressure in the arteries and arterioles that irrigate the eye [3].

According to the format of the camerular sinus, Glaucoma is divided in Open-Angle and Angle-Closure [4]. Classically, it is known that Angle-closure Glaucoma is more aggressive than Open-angle Glaucoma for reaching extremely high intraocular pressure levels, due to the closure of the camerular sinus which is the main drainage structure of the aqueous humor. Uus, identifying the type of Glaucoma is important towards taking appropriate action.

Ue objective of this study is to present a new diagnostic approach using an existing technology: the optical coherence tomography (OCT). Ue innovation lies in how to use the OCT device.

Justification

OCT has revolutionized the diagnosis in ophthalmology through this method that is quantitative; that is, it measures size, thickness and structural dimensions, regardless of the information provided by the patient. When combined with clinical reasoning, there is a very accurate or improved detection of what is normal range and what has been altered. Although not yet routinely used, the investigation of the camerular sinus through the anterior segment OCT (OCT-SA) provided us with images of the format of this structure; however, this technique is currently performed with the patient sitting.

For the detection of the most aggressive type of glaucoma, which is Angle-closure glaucoma, the ideal test would be OCT in prone position. Historically speaking, by the way, there are techniques that indirectly would lead to this diagnosis, such as the dark room test [4,5], the prone position test [6] and the combination of the latter two [7].

In the literature, available data on the dark room test, initially described in 1954, indicate the possibility of identifying "congestive glaucoma" in a variable number of patients, with a positivity observed from 11% to 78% of glaucoma cases [4]. On the other hand, a study analyzing the prone position test in Angle-closure suspects, showed positivity in around 48.6% of the cases [6].

Both through the dark room technique and the prone position technique, the intraocular pressure is measured, being its variation, an indirect measure of the occlusion of the camerular sinus; narrow-angle patients would increase intraocular pressure more than open-angle patients. For practical reasons, these tests were practically abandoned.

Currently, with the existence of OCT technology, we can use one of its features (visualization of live images of the anterior segment of the eye) in order to visualize what happens with the camerular sinus, at the moment of the prone position. Uis kinetic image of the OCT is usually used when capturing the image of the camerular sinus. We would use this feature of the device to visualize, live, the image of the camerular sinus. Uis way, we would be able to identify the narrowing that occurs in the camerular sinus before and aIer prone position;

thus, we could early identify people who will develop angle-closure glaucoma or even people who have already been diagnosed with open-angle glaucoma may have their status changed to angle-closure glaucoma. One must keep in mind the elastic nature of the tissues that make up the camerular sinus.

To date, no patient has been placed in prone position that is associated with a compatible positioning of the OCT apparatus. Our model proposes equipment that places the patient in prone position and also changes the positioning of the OCT device so that, taking advantage of the characteristics studied from the association of these aspects, they can generate the improvements suggested in this report.

In our model, we will investigate the main drainage area, the camerular sinus, through the optical coherence tomography. Uis technology currently captures images of the patient in a seated position, as shown in Figure 1.

Figure1: Technology currently captures images of the patient in a seated position

As the crystalline support tissue, which is in close contact with the iris, has elastic fibers in its constitution, people who have not yet undergone cataract surgery and undergo the test in prone position may present with a narrowing of the camerular sinus. Uis is because with the action of gravity, the weight of the lens can push it down, against the iris. It is justified, therefore, the closing moments of the camerular sinus when the patient is sleeping, when it is not possible for the physician assistant to measure the patient's ocular pressures. We believe that many cases of normal pressure glaucoma are actually cases of glaucoma associated with ocular hypertension when the patient is sleeping.

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Description of the Oct Technique in Prone Position

We have developed a theoretical system of identification of the camerular sinus type which can improve the diagnosis of closed-angle glaucoma. the improved system for optic coherence tomography, object of this article, consists of an apparatus for performing OCT examination of the anterior segment in the lying position with the patient looking down, using a massage stretcher or the like, with the arrangement of an adapted head rest at one end; this would avoid any type of direct or indirect compression in the patient's eye, making it possible to perform the examination more precisely, with the guarantee of an accurate result and consequent elaboration of a correct diagnosis of the patient. What we do is adapt current technology to the creation of those colleagues who innovated in their time.

OCT in prone position also comprises an OCT apparatus positioned 90° from its original position (the front of the eyes), but facing the patient's eyes. Ue adapted support in the stretcher allows the examination to be performed. It should also be clear that the support sets up a head rest that leaves the eye area free to perform the OCT in prone position.

Technically, the method of examination remains the same, but with a differentiated methodology, since the glaucoma patient, when placed in prone position, may have a closure of the drainage area of the pressure (camerular sinus) due to the elastic tissue that composes the internal structures that support the lens and its relation to the iris.

Ue OCT device is positioned below the patient's eye and it captures the live image at the very moment when the patient is in prone position. Ue basic difference from the traditional technique is that, in the latter, the examination is not performed in the prone position but in the seated position. Uis seated position does not cause the closure, except in advanced cases. At the moment of closure of the drainage area, it is possible to verify it through the anatomical visualization of the touch of the two structures that are the iris and the posterior face of the cornea located between the Schwalbe's line and the scleral spur, both identifiable to OCT-SA. In addition to that, pressure can be measured by means of a portable tonometer that can corroborate with this data of the visualization of the closure of the pressure area by measuring the increase in the intraocular pressure.

Simulation of OCT Images with Patient in Prone Position

Urough this technique we can get to know if there is an influence of the shape of the camerular sinus in all cases of glaucoma or if there are actually distinct physiopathogenesis between open-angle glaucoma and closed-angle glaucoma. With the use of the OCT, it is possible to observe the closure and opening of the camerular sinus angle only with the examination in bright light and in a dark room, which can be seen in Figures 1-5.

Figure 2: In this 3D simulation of OCT imaging, the patient lies down on a stretcher, and the part of the OCT that emits the lasers is located just below the patient's eyes.

Figure 3: Ue part of analysis and exposure of data and images (computer) is located elsewhere, making it possible for the technician to perform the exam ergonomically.

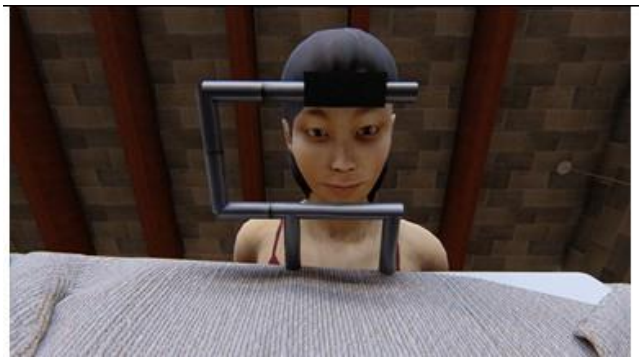

Figure 4: It is noticed that the support for the face leaves the eyes totally free of any lateral or frontal pressure, allowing a collection of exams without any direct or indirect pressure on the eyes. Uis could interfere with the exam result.

Figure 5: Uis could interfere with the exam result

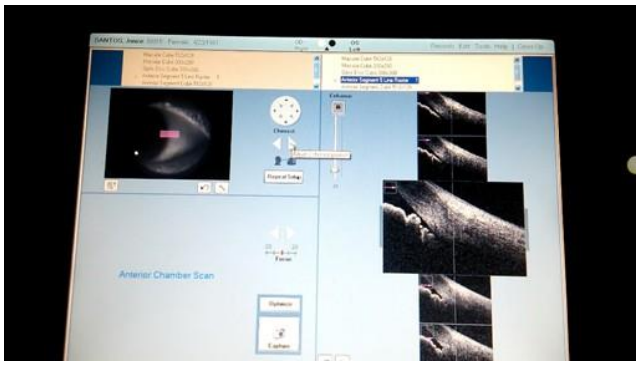

Figure 6: OCT image at the time of capture of the camerular sinus image (anterior chamber angle), in this case, showing a narrow angle. At this moment the room was dark and the patient was sitting.

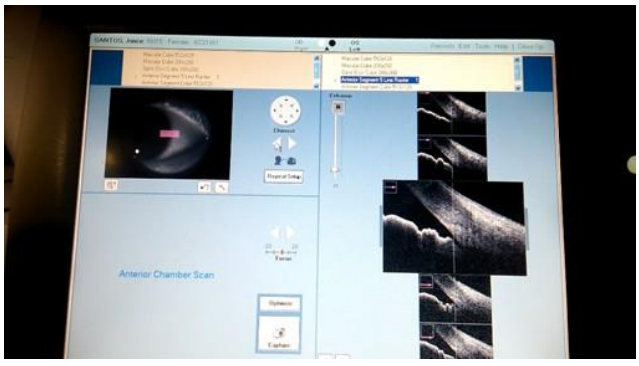

Figure 7: OCT image at the time of capture of the camerular sinus image (anterior chamber angle), in this case, showing open angle. At this moment the light was on and the patient was sitting.

On the other hand, the examination considered gold standard in the diagnosis of the camerular sinus between open angle and angle closure depends on visible light to be performed, a condition that stimulates the closure of the pupil and can olen confuse the physician in this differentiation in favor of the visualization of the open angle.

Ue technique that we created is an improvement of the technique idealized by Hyams et al. [6]. As OCT did not exist at that time, the identification of the patient with closed-angle glaucoma was done by comparing the IOP measurements before and aler a time with the patient in prone position. Before Hyams, it is necessary to emphasize the dark room test, created by Higgitt [4] which had the same purpose of the prone position test. Later on, other authors, such as Kim et al. [7] combined the two techniques through the dark room prone position test. All these techniques were created in order to optimize the diagnosis of angle-closure glaucoma, the largest contributor to the new cases of blindness from this disease [8].

Ue use of the improved system for the Optical Coherence Tomography in prone position will present an undisputed objective measure of what happens in the camerular sinus of glaucoma patients and ideally promote a method that can identify people who will develop glaucoma even before any manifestation of this disease. Likewise, this method will allow preventive interventions in order to correct the anatomical alterations that give rise to glaucoma.

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