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# In Vivo Insights: Vitreous Dynamic Study Using SS-OCT System

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## 1. Introduction

Vitreous is a transparent, gelatinous, avascular gel that fills the majority of the eyeball, occupying the space between the lens and retina. It plays a crucial role in maintaining the structural integrity of the eye and in facilitating light propagation to the retina. Changes in the biomechanical properties of vitreous, often associated with aging and myopia, lead to its liquefaction and opacification. These alterations contribute significantly to vitreous degeneration, which in turn influences the pathogenesis of various vitreo-retinal diseases, including retinal detachment and vision degrading myodesopsia [1]. Vitreous degeneration processes affect vitreous dynamics, which also impact overall ocular health and function [2]. Therefore, characterizing vitreous dynamics during saccadic eye movements can be essential for understanding pathological changes within the vitreous body. Such characterization can also provide a quantifiable clinical index of disease severity in conditions like vision degrading myodesopsia resulting from both aging and myopia [3]. By gaining insights into these dynamics, we can improve diagnostic and therapeutic strategies for managing vitreo-retinal disorders.
This study aims to better understand the dynamics of the vitreous during eye movement. Specifically, we describe a new technique for in vivo measurement of vitreous movement tracked over time using high-speed swept-source optical coherence tomography (SS-OCT) imaging. This advanced imaging modality allows for detailed visualization of the vitreous structure, despite its high-water content and transparency. Additionally, we developed a sophisticated velocimetry analysis of 3D OCT data sets, enabling us to characterize the velocity distributions of vitreous opacities in both emmetropic and myopic eyes during eye movements, specifically horizontal saccades. By analysing the movement and behaviour of these opacities, we can gain insights into the biomechanical properties of the vitreous and how they differ between normal and myopic eyes. This approach not only enhances our understanding of vitreous dynamics but also provides valuable information for diagnosing and managing vitreo-retinal diseases associated with vitreous degeneration.

## 2. Methods and results

In vivo eye imaging of the human subjects was performed using a state-of-the-art prototype swept-source optical coherence tomography (SS-OCT) instrument (Fig. 1). This advanced device operates at a central wavelength of 1060 nm, with a wavelength tuning range of 80 nm, allowing for comprehensive and high-resolution imaging across a wide spectral range. The SS-OCT system features a sweep rate of 100 kHz, enabling rapid data acquisition and minimizing motion artifacts during imaging. We achieved a sensitivity of 103 dB with an incident power of 1.8 mW on the object, ensuring that even subtle structural details within the vitreous humour could be visualized clearly. The axial imaging range was 4 mm and the axial resolution of 10 µm in the air was measured and providing the necessary high-definition imaging capabilities to identify and analyze minute changes within the vitreous body.

Each single 3-D scan performed by the SS-OCT instrument consisted of 240 A-scans and 60 B-scans. This configuration ensured comprehensive coverage of the imaging area (9 × 9 mm2) and allowed for detailed examination of the vitreous structure and dynamics. The time period for capturing a single frame was 2 ms, enabling the system to perform rapid imaging sequences that are essential for studying the dynamics of the vitreous during saccadic eye movements. This high-speed imaging capability, combined with the high resolution and sensitivity of the SS-OCT system, allowed us to conduct detailed velocimetry analysis of vitreous opacities. By analyzing the velocity distributions of vitreous opacities, we were able to characterize the biomechanical properties of the vitreous in both emmetropic and myopic eyes during horizontal saccades.

The study adhered to the tenets of the Declaration of Helsinki and included 9 subjects (2 emmetropes, and 8 myopes mean age 28.4 ±4.8 years). Each eye was measured under the condition with saccadic motion at a 10-degree angle. Accordingly, the condition subjects were asked to look straight ahead and to make a voluntary horizontal motion at a 10-degree angle by looking at the screen. The scanning procedure commenced promptly, synchronizing with sub-saccadic eye movements spanning from 0 to 10 degrees. Each position, at 0 degrees and 10 degrees, was held for 4 seconds. Throughout this process, we are acquiring 3D datasets of both the retina and vitreous, and promptly generating enface projections.

In this preliminary report, we present the 3-D OCT tomograms spanning the depth of the posterior segment to visualize posterior vitreous and vitreous floaters and employing enface projection techniques, we generated images depicting the retina and posterior vitreous, showcasing the visualization of vitreous opacities. These images are illustrated in Fig. 1.

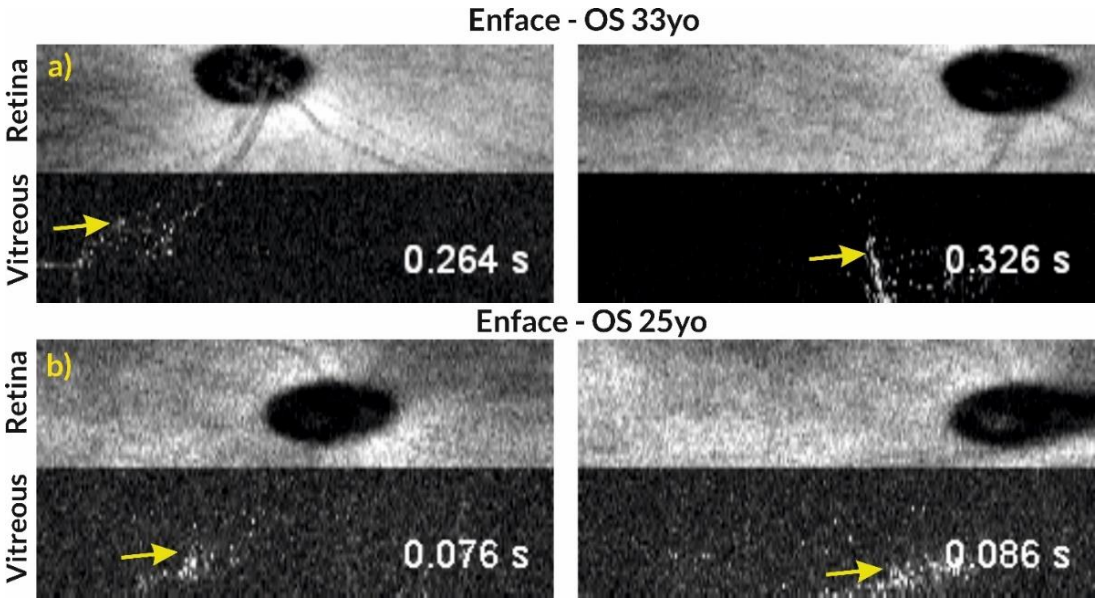


Fig. 1. The human eye vitreous was measured in vivo with SS-OCT. En-face showing posterior vitreous body opacities and the retina. (a) Left eye of a 33-yo subject with sub-saccadic movement 0 to 10-degree (b) Left eye of a 25-y.o. subject undergoing similar sub-saccadic movement. The yellow arrow indicates the movement of vitreous opacities the same over time.

We demonstrate the ability to visualize the motion of the posterior vitreous in vivo using SS-OCT. Velocity analysis enables assessment of vitreous dynamics quantitatively. Vitreous velocimetry could be a potential marker for vitreous liquefaction assessment. This approach can contribute to research as well as clinical assessment of vitreous biomechanical properties in health and disease.

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## 4. References

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