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Case Report

Visualization and Identification of Silicone Oil Emulsification Using Dynamic Infrared Confocal Scanning Laser Ophthalmoscopy

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Keywords

Silicone oil · Emulsification · Droplets · Dynamic · Infrared confocal scanning laser ophthalmoscopy

Abstract

Introduction: Silicone oil (SO) is a crucial agent used as an intraocular tamponade in the treatment of complex vitreoretinal diseases. Despite its effectiveness, SO is prone to emulsification, which can lead to significant and sometimes irreversible complications in both the anterior and posterior segments of the eye. The detection and monitoring of SO emulsification are therefore of paramount importance. Traditional imaging modalities have limitations in visualizing SO, leading to the exploration of more advanced imaging techniques. This study introduces the application of dynamic infrared confocal scanning laser ophthalmoscopy (IRcSLO) for this purpose and evaluates its effectiveness. ***Case Presentation:*** We report on 2 patients who underwent pars plana vitrectomy with subsequent SO injection for the management of retinal detachment. Postsurgery, both patients were imaged using the Heidelberg Retina Tomography Spectralis IRcSLO. The focus was on the visualization of the SO status, including the presence and distribution of emulsified SO droplets. The IRcSLO imaging technique demonstrated its capability to effectively visualize emulsified SO droplets. Interestingly, this was also true for cases where the SO had been removed. The emulsified droplets were observed as micron-sized, spherical entities with a nonuniform distribution throughout the vitreous cavity. ***Conclusion:*** Dynamic IRcSLO has

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proven to be an effective imaging modality for visualizing the emulsification of SO, offering a novel perspective into the characterization of SO droplets. It facilitates the analysis of droplet count, motility, and precise localization within the vitreous cavity. The findings from the case presentations underscore the variability of SO emulsification patterns and the sensitivity of IRcSLO in detecting even minuscule emulsified droplets. This imaging technique has significant potential for future research, particularly in understanding the timing of emulsification, the factors contributing to it, and the development of possible preventive strategies. Additionally, it allows for a more in-depth analysis of the behavior of emulsified SO droplets across different SO viscosities, which could be instrumental in optimizing patient outcomes.

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Introduction

Silicone oil (SO) is a liquid composed of repetitive Si-O units that is used as an intraocular tamponade in the surgical management of complex vitreoretinal diseases [1, 2]. A significant complication of SO use is emulsification, which can trigger several irreversible numbers of both anterior and posterior segment adverse events [2]. Hence, the early detection of SO emulsification is critical to prevent such complications.

Despite this necessity, traditional imaging techniques often fall short when trying to visualize SO, similar to the hurdles encountered while imaging the vitreous. This problem can be solved using scanning laser ophthalmoscopy (SLO) imaging, which has been recently used to image the vitreous floaters and opacities [3–7].

In this report, we explored for the first time the use of dynamic SLO imaging in a spectral domain-optical coherence tomography device to visualize emulsified SO droplets.

Imaging Technique and Case Presentation

This study included 2 patients who underwent pars plana vitrectomy with SO injection for complex retinal detachment and were imaged at Clinical University Hospital of Valladolid (Valladolid, Spain). The study was approved by the Institutional Ethics Committee of the Clinical University Hospital of Valladolid (CEIC Valladolid Oeste; approval number PI 22-2716) in accordance with the Declaration of Helsinki.

Infrared Scanning Laser Ophthalmoscopy

For each patient, the eye was scanned two consecutive times by an experienced trained ophthalmologist prior to clinical examination. All participants were fully dilated with 1% tropicamide and 2.5% phenylephrine.

Standard infrared confocal scanning laser ophthalmoscopy (IRcSLO) dynamic images of the affected eye were obtained using the Heidelberg Retina Tomography Spectralis SLO (Heidelberg Engineering, Heidelberg, Germany), which uses an SLO laser of 820 nm (near-infrared) and operates at 40,000 A-scans per second. Videos were recorded using the software included in the device (Heidelberg Eye Explorer, Version 1.10.2.0) and the complete acquisition time of each scan lasted between 30 and 60 s.

As we demonstrate below, this imaging technique allows the visualization of the SO status and the presence of SO-emulsified droplets. It is based on the principle of infrared reflection contrast, where the refractive index of the SO droplets is different from the surrounding medium, leading to a contrast in infrared image. Videos were analyzed by a single reader (SPI) that was not masked by patient symptoms.

Case 1

A 57-year-old male presented with a 6-day history of severe vision loss in his right eye (OD). Examination revealed best-corrected visual acuity of 0.9 logMAR, posterior vitreous detachment, and rhegmatogenous retinal detachment with macular involvement. Surgical intervention included a 23-G pars plana vitrectomy and high-density SO (5,000 cs) injection. At 5-week postoperative, the ophthalmologic examination revealed an attached retina. IRcSLO demonstrated hyperreflective clusters of emulsified oil mimicking "floating islands" within the vitreous cavity and the presence of smaller less hyperreflective SO droplets, as is shown in Figure 1.

Case 2

A 62-year-old male attended the emergency department due a sudden onset of floaters and perception of a "black curtain" in his left eye (OS). His best-corrected visual acuity was 1.0 logMAR. Indirect ophthalmoscopy with scleral indentation demonstrated a vitreous hemorrhage, Weiss ring, and two temporal horseshoe retinal tears. In spite of using laser photocoagulation to treat these tears, a rhegmatogenous retinal detachment was developed 2 days later. Subsequently, a 23-G pars plana vitrectomy using 1,000 cs SO injection was performed. The SO endotamponade lasted 3 months. Real-time IRcSLO videos were obtained after SO removal (SOR). Despite the absence of evident clusters of SO, tiny emulsified SO droplets were still observed within vitreous cavity, which are demonstrated in Figure 2. The CARE Checklist has been completed by all the authors for this case report, which is attached as online supplementary material (for all online suppl. material, see https://doi.org/10.1159/000535746).

Discussion

SO emulsification is a well-known adverse event that remains a significant challenge due to its potential wide range of severe and irreversible complications [2]. Traditional examination techniques, such as slit-lamp biomicroscopy, gonioscopy and fundus photography, may not provide sufficient detail to identify small SO droplets and its dynamic behavior within the eye [8]. Thus, there is a need of more sensitive and specific imaging techniques for the early detection of SO emulsification.

The use of real-time imaging techniques such as IRcSLO has become commonplace not only in retina but also in vitreous examination [3–7]. Recently, the near-infrared images produced by IRcSLO have been used to visualize vitreous floaters and opacities, evident as shadows projected onto the retinal surface [3–7]. However, as far as we know, the presence of SO emulsification in real-time IRcSLO has not been described yet.

In our patients, the IRcSLO imaging technique was able to effectively visualize emulsified SO droplets, which were seen as micron-sized, spherical entities in all cases that underwent SO injection. The distribution of these droplets was also distinctly evident and SO tended to appear in the superior retina, especially in the SOR case. SLO of the vitreous cavity provided a real-time evaluation of SO status. This imaging technique may help clinicians to monitor emulsification and may also be a decision-making tool to plan SOR. We believe that dynamic IRcSLO is a powerful imaging technology and technique that enables an objective visualization of SO emulsification. IRcSLO may better reveal the number of droplets, their motility, and the localization within the vitreous cavity. Hence, this technology possesses the capability to accurately reproduce "in vivo" the often-underestimated visual symptoms experienced by patients with SO-filled eyes. Furthermore, SLO may serve as a complementary tool to

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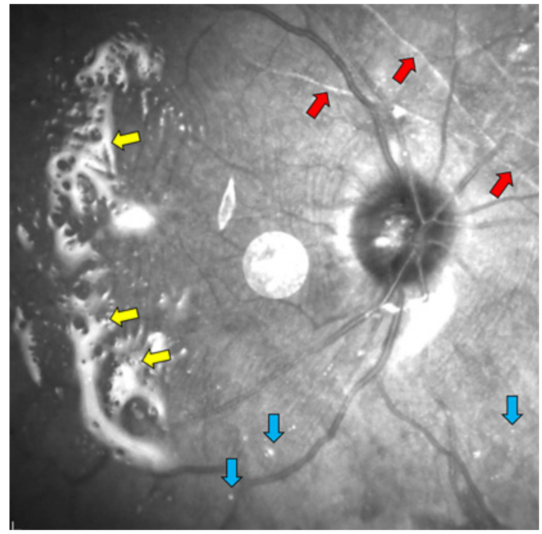

Fig. 1. Case 1. Sectorial IRcSLO image of an SO-filled eye demonstrates clusters of emulsified SO creating "floating islands" (yellow arrows), tiny isolated emulsified SO droplets (blue arrows), and attached retina with demarcation lines (red arrows).

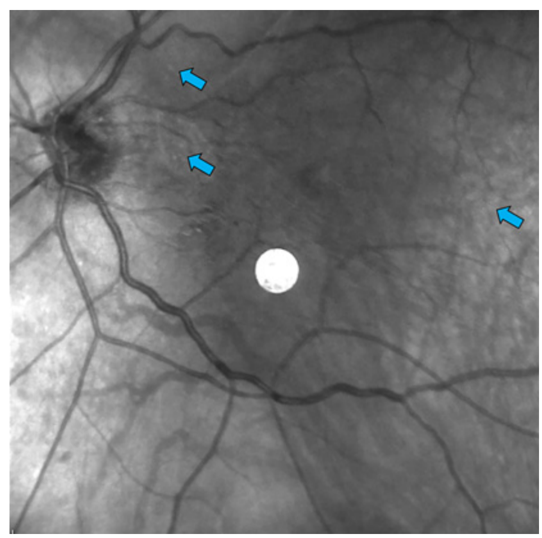

Fig. 2. Case 2. Sectorial IRcSLO image of an SOR eye shows small and mild hyperreflective emulsified SO droplets (blue arrows).

objectively grade SO emulsification and identify variations in behavior between low- and high-density SO. Another potential clinical application for this diagnostic technique is the education for patients, their families, and the junior doctors.

Using this noninvasive proposed technique, further studies can provide new insights into the timing and factors that contribute to emulsification, as well as potential ways to prevent it. This technique can also be used to study the structure and dynamics of emulsified SO droplets, aiming to understand the underlying mechanisms of its emulsion stability and rheology in the different SO viscosities.

Statement of Ethics

The study was approved by the Institutional Ethics Committee (Code: PI 22-2716) in accordance with the Declaration of Helsinki. Written informed consent was obtained from participants for the publication of the details of their medical case and any accompanying images.

Conflict of Interest Statement

All authors have no financial disclosures or conflicts of interest to declare.

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Author Contributions

F.J.V.-B., P.E.S., and S.E.F.S.: manuscript drafting and analysis. F.J.V.-B., S.A.M.-T., and S.M.S.: data acquisition. F.J.V.-B., P.E.S., S.A.M.-T., S.M.-F., S.E.F.S., R.U.-M., C.A.-I., and S.P.-I.: manuscript final review. S.P.-I.: corresponding author.

Data Availability Statement

The authors confirm that the data supporting the findings of this study are available within the article. Further inquiries can be directed to the corresponding author.

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