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Data Article

Physiology of retinal reattachment in humans: Swept source optical coherence tomography imaging data supporting a novel staging system

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ABSTRACT

This article presents high-resolution swept source optical coherence tomography (SS-OCT) imaging data used to describe the physiology of retinal reattachment in humans. SS-OCT imaging was performed at baseline and every 2 h for the first 6 h and at frequent intervals thereafter up to 6 weeks following the injection of intravitreal gas in eyes undergoing pneumatic retinopexy for rhegmatogenous retinal detachment. Imaging data presented in this article is related to the research paper titled "*Real-Time in Vivo Assessment of Retinal Reattachment in Humans using Swept-Source Optical Coherence Tomography*" (Bansal et al., 2021). SS-OCT images were assessed longitudinally and used to devise a novel staging system that describes the physiology of retinal reattachment.

Abbreviations: SS-OCT, Swept Source Optical Coherence Tomography; RRD, Rhegmatogenous Retinal Detachment; PnR, Pneumatic Retinopexy; RPE, Retinal Pigment Epithelium; ELM, External Limiting Membrane; EZ, Ellipsoid Zone.

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Multiple examples of each stage and the transition from one stage to the next are provided. SS-OCT images were also assessed to determine the timing associated with each stage, and the anatomic abnormalities, such as outer retinal folds and subretinal fluid blebs that occured as a result of delayed progression through certain stages.

Specifications Table

Subject	Ophthalmology
Specific subject area	Physiology of Retinal Reattachment in Humans
Type of data	Images - Figs. 1–5 - Raw Data
How data were acquired	High resolution swept-source optical coherence tomography imaging using the Carl Zeiss PLEX® Elite 9000 (Carl Zeiss, Dublin, California, USA)
Data format	Processed SS-OCT images in TIFF format.
Parameters for data collection	Patients with rhegmatogenous retinal detachment with a single or multiple retinal break(s) within 3 clock hours in detached retina above the 8 and 4 o' clock meridians with any number, location and size of retinal breaks or lattice degeneration in the attached retina, proliferative vitreoretinopathy $\leq$ grade B, undergoing treatment with pneumatic retinopexy.
Description of data collection	High definition horizontal 1 line spotlight scan (100x) and a 12 $\times$ 12 mm cube (512 $\times$ 512) images were obtained with Carl Zeiss PLEX® Elite 9000 SS-OCT at presentation and at 2,4,6 h and at day 1, 2, 5, and at week 1, 2, 4 and 6 following pneumatic retinopexy for rhegmatogenous retinal detachment repair. Additional imaging was also performed at 3 months in the majority of patients.
Data source location	St Michael's Hospital, Unity Health Toronto, Toronto, Ontario, Canada.
Data accessibility	Imaging data: Figures are hosted with the article. Raw Data has been uploaded to a data repository: https://data.mendeley.com/datasets/ddctbdygps/draft?a=7cc761a8-3738-484d-adad-4942f3ed7cb2
Related research article	Bansal A, Lee WW, Felfeli T, Muni RH. Real-Time In Vivo Assessment of Retinal Reattachment in Humans using Swept-Source Optical Coherence Tomography. *Am J Ophthalmol.* 2021;227:265-274. doi:10.1016/j.ajo.2021.02.013

Value of the Data

- The real-time in vivo imaging data presented in this article demonstrates the OCT based stages of retinal reattachment in greater detail with several examples for each specific stage. This will enable researchers and clinicians to recognize each stage and potentially use the imaging features of certain stages as imaging biomarkers in studies assessing outcomes following retinal detachment repair.
- This imaging data is useful for ophthalmologists and retina specialists who assess patients before and after retinal detachment repair to understand the anatomic basis of their functional outcomes.
- Other investigators may use this data to help design additional studies with a larger number of patients to assess the timing of the various stages of reattachment over a longer duration. Furthermore, data from this study could be extrapolated to determine potential variations to certain stages with different surgical maneuvers.
- The SS-OCT images help inform the physiology of retinal reattachment in humans which is being visualized in vivo in detail for the first time.

- Assessment of this data allows for a deeper understanding of how various anatomic outcomes such outer retinal folds and subretinal fluid blebs develop from delayed progression through certain stages of reattachment. This knowledge is critical to understanding how the anatomic outcomes could potentially be avoided with different surgical techniques.
- Additional studies utilizing this data as a guide can be performed to determine the functional outcomes associated with various stages of reattachment.

1. Data Description

These imaging data demonstrate the physiology of retinal reattachment visible in real-time using *Swept-Source Optical Coherence Tomography* (SS-OCT). Reattachment of every point on each patient's retina occurred in 5 specific stages (Figs. 1–5). Although the stages of reattachment could be applied to any point on the retina, the emphasis for this dataset was on the fovea.

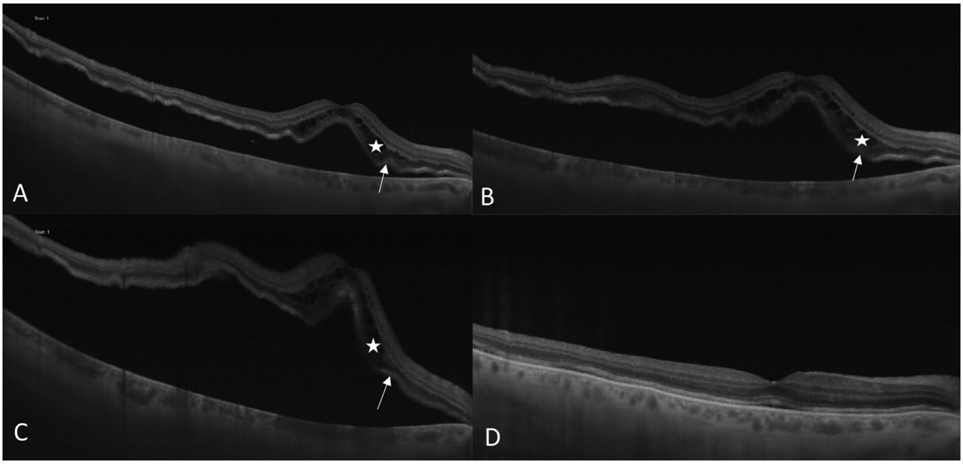

Fig. 1. (Case 10): Progression from Baseline to Stage 1&2 A) Baseline swept-source optical coherence tomography image in the right eye demonstrating rhegmatogenous retinal detachment, along with the presence of cystoid macular edema (star) and outer retinal corrugations (arrow). B & C) Following pneumatic retinopexy (PnR), redistribution of subretinal fluid is noted, which can result in an initial increase in height of the detachment due to posterior displacement of subretinal fluid by the gas bubble (stage 1). D) Subsequently the retina has approached towards the RPE (stage 1) and improvements in cystoid macular edema (likely related to improved metabolic transfer between the retina and the RPE) and outer retinal corrugations are noted (Stage 2).

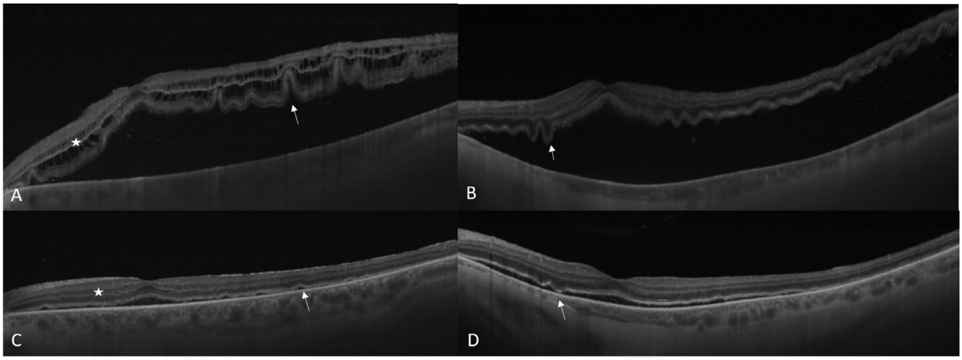

Fig. 2. (Cases 9 & 1): Progression from Stage 1 to Stage 2 A & B) Swept-source optical coherence tomography image in the left eye demonstrating approach of neurosensory retina towards RPE along with the presence of cystoid macular edema (star) and outer retinal corrugations (arrow) following pneumatic retinopexy (PnR) (Stage 1). C & D) 24 h later there is a substantial reduction in cystoid macular edema (star) and improvement in the frequency and height of the outer retinal corrugations (arrow) is noted (Stage 2).

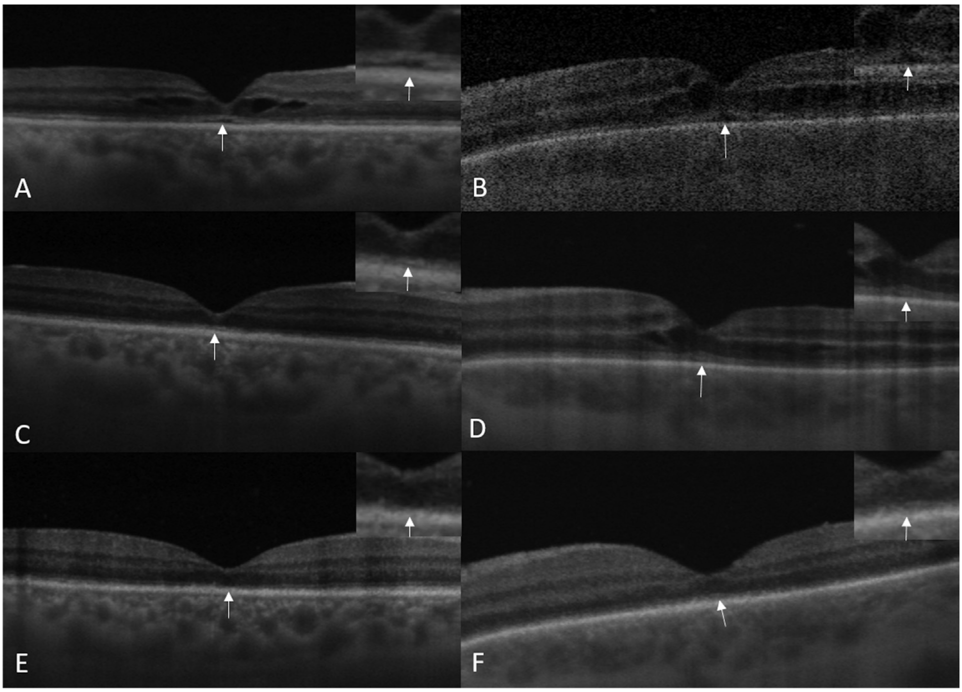

Fig. 3. (Cases 15 & 7): Progression from Stage 2 to Stage 3&4 A & B) Swept-source optical coherence tomography image demonstrating Stage 2 i.e. resolving cystoid macular edema and improvement of outer retinal corrugations, along with thickened inner and outer segments of photoreceptors (arrow) and the absence of retina-RPE contact at the fovea. C & D) There is progression to Stage 3 with contact of the neurosensory retina with the RPE (arrow) with some thickening of the photoreceptor layer (arrow). C & F) Complete deturgescence of the photoreceptors (with reduced thickening of the photoreceptor layer [arrow]) occurring in Stage 4.

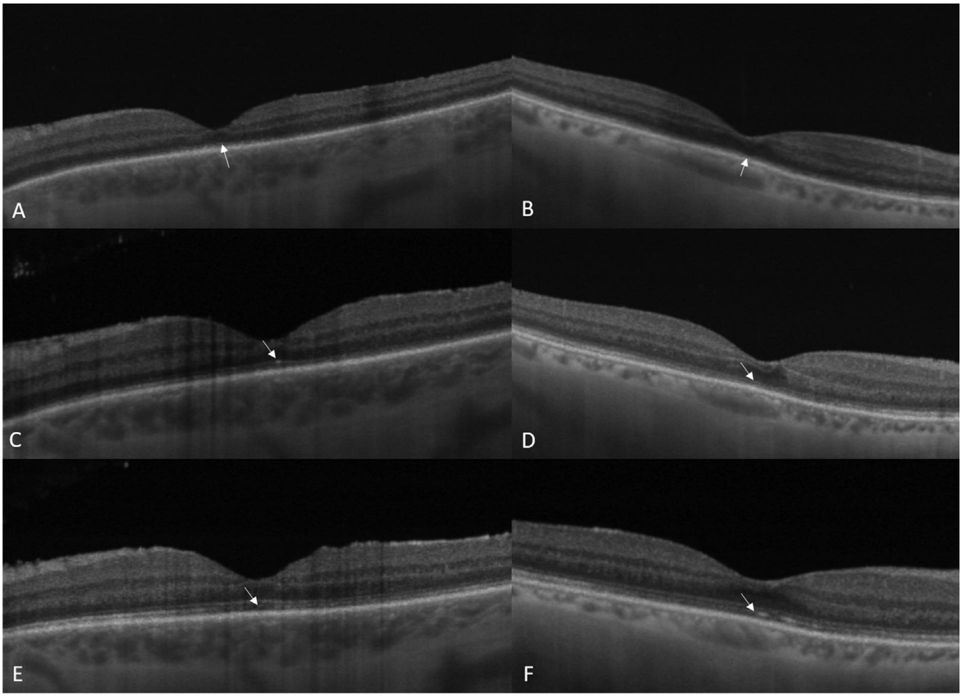

Fig. 4. (Cases 7 & 4): Progression from Stage 3 to Stage 4&5 a,b A & B) Swept-source optical coherence tomography image demonstrating complete deturgescence of photoreceptors with absence of external limiting membrane (ELM) and ellipsoid zone (EZ) integrity (arrow). C & D) Recovery of photoreceptor integrity, ELM (Stage 5a) (arrow). E & F) Recovery of photoreceptor integrity EZ (Stage 5b) (arrow).

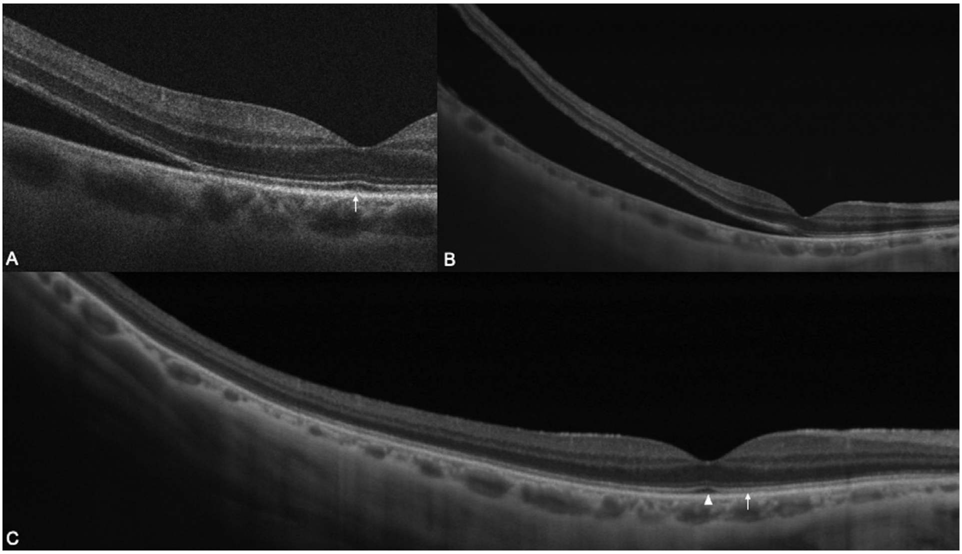

Fig. 5. (Case 8): Progression to Stage 5c A) Baseline spectral-domain optical coherence tomography image of a 52-year-old male demonstrating rhegmatogenous retinal detachment (RRD) in the right eye that was fovea on (arrow) at the referring doctor's office. B) Swept-source optical coherence tomography of the same patient when he presented to our office on the same day with progression to a fovea-split RRD. C) Following pneumatic retinopexy (PnR) there is recovery of the interdigitation zone (arrow) and foveal bulge (arrowhead) (Stage 5c) within 6 weeks of PnR.

2. Experimental Design, Materials and Methods

This was a prospective cohort study for patients enrolled between July and September 2020 at St Michael's Hospital/Unity Health Toronto, Toronto, Canada. We enrolled consecutive patients undergoing pneumatic retinopexy with primary fovea-off RRD. Inclusion and exclusion criteria were as described by Bansal et al. [1]. All patients underwent a thorough scleral-depressed peripheral retinal examination to identify all pathologic features. Pneumatic retinopexy was performed as described in the PIVOT trial (Hillier et al) [2].

Imaging was performed as described by Bansal et al. [1] using Carl Zeiss PLEX® Elite 9000 Swept Source Optical Coherence Tomograph. SS-OCT differs from SD-OCT in that it does not require a charge-coupled device camera and spectrometer and instead uses a metal oxide semiconductor camera and photodiode detector. Also, instead of a super-luminescent diode laser it uses a short cavity swept laser of a narrow bandwidth (Srinivasan et al.) [3]. Because of these technological advancements, SS-OCT has superior image acquisition which allows for denser and wider scans. Due to decreased sensitivity roll-off SS-OCT can image deeper structures with enhanced visualization of the outer retina, RPE and choroid and a better ability to highlight the vitreous with less impact from media opacity (Choma et al.) [4]. With SS-OCT there is a trade-off with worse signal-to-noise ratio and image resolution, although this can be compensated for with the high averaging rate. In this study we used the 1-line spotlight scan with 100 times averaging. These scans where 16 mm long which allowed for a wider field of view which is not possible with the SD-OCT. This allowed us to assess more points on the retina that could be assessed to validate the novel staging system. Finally, the high-speed image acquisition was particularly helpful for eyes with poor fixation as a result of the macula-off RRD. Patients were imaged frequently in order to assess specific changes occurring to the retina during the reattachment process with pneumatic retinopexy. While the macula was detached, the tracker was kept off and we aimed to obtain an image of the foveal region. Once the retina was attached, the FastTrac^{TM} was used to acquire the images. This enabled us to scan the exact same area (i.e., the fovea) at every time point, which allowed for proper documentation of morphological changes that occur in the retina during the reattachment process.

The primary outcome was the early longitudinal post-operative SS-OCT changes after PnR to assess the in vivo human physiology of retinal reattachment in real-time and to determine the stages of reattachment.

Ethics Statement

This study was approved by the Research Ethics Board at St. Michael's Hospital/Unity Health Toronto in Toronto, Canada, and adhered to the Declaration of Helsinki. All human subjects were recruited after written informed consent.

Declaration of Competing Interest

None.

CRediT Author Statement

Aditya Bansal: Methodology, Data curation, Investigation, Writing – original draft; **Wei Wei Lee:** Conceptualization, Methodology, Resources; **Tina Felfeli:** Methodology, Data curation, Resources; **Rajeev H. Muni:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Supervision.

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