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Review

# Advanced Preoperative Imaging in Macula-Off Rhegmatogenous Retinal Detachment: Emerging Diagnostic and Prognostic Insights for Clinical Management

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## Abstract

Retinal detachment (RD) is a potentially sight-threatening condition that requires timely diagnosis and appropriate surgical management. In macula-off rhegmatogenous retinal detachment (RRD), visual recovery after successful reattachment remains highly variable, underscoring the need for reliable preoperative prognostic markers. This study focuses on the contribution of advanced retinal imaging to the preoperative assessment of macula-off RRD, summarizing current evidence on imaging-derived biomarkers associated with disease severity and postoperative functional outcome. In this review, we analyze studies employing spectral-domain and swept-source optical coherence tomography (SD-OCT and SS-OCT), OCT angiography (OCT-A), and adaptive optics OCT (AO-OCT) to characterize microstructural and microvascular retinal alterations. Emerging approaches, including ultra-widefield OCT (UWF-OCT) and artificial intelligence-based image analysis, are also discussed for their potential role in refining diagnosis, supporting surgical planning, and improving prognostic stratification. While several imaging parameters appear promising, their prognostic value is not yet fully standardized. Further prospective studies are required to validate clinically meaningful imaging biomarkers and to integrate advanced imaging into routine preoperative decision-making for macula-off rhegmatogenous retinal detachment.

**Keywords:** artificial intelligence; macula-off retinal detachment; optical coherence tomography; preoperative imaging; retinal biomarkers; rhegmatogenous retinal detachment; ultra-widefield imaging

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## 1. Introduction

Retinal detachment (RD) represents a potential sight-threatening condition requiring rapid clinical assessment and correct treatment, to avoid irreversible legal blindness. This pathological entity is characterized by the separation of the neurosensory retina from the underlying retinal pigment epithelium (RPE). RD incidence is variable but globally affects roughly 6 to 18 patients per 100.000 every year, with demographic, geographic differences and increasing incidence in last decades [1,2].

The prevailing form is Rhegmatogenous RD (RDD), due to the presence of a retinal break, "rhegma" in antique Greek, that enables the entrance of liquified vitreous under the neurosensory

retina and subsequently splitting the mentioned layers [3]. However, there are other forms of retinal detachment, exudative and tractional, with different pathophysiological mechanisms, that are not discussed in this article [4,5]. It is mandatory, in the clinical assessment and for treatment purposes, consider the extension of the RD and the possible involvement of the macula, the noble retinal region containing the fovea, fundamental for central detailed vision. On this aspect, RRD is therefore classified in “macula-on” and “macula-off” retinal detachment. This review focuses on “macula-off” RRD, which is associated generally with challenging treatment approaches and poorer visual prognosis, compared to macula-on RRD, despite innovative surgical techniques and early treatment [6,7].

Retinal reattachment is achieved in about 90% of cases, using different techniques available nowadays, like scleral buckling (SB), pars plana vitrectomy (PPV) or combination of these [6,7]. However, postoperative functional outcomes are variable, due to numerous different pre-operative and post-operative factors, like baseline best-corrected visual acuity (BCVA), macula involvement, extent of RD, onset and duration of preoperative symptoms, vitreous tractions [8,9].

Concerning macula-off RD, due to the anatomical extent of macular region and timing-dependent condition, prompt clinical assessment plays a crucial role to reducing the risk of irreversible vision loss and setting the correct surgical management [10–12].

Traditional clinical examination testing BCVA, Amsler test and fundoscopy provide limited qualitative information. Modern advanced retinal imaging techniques, in particular spectral-domain and swept-source optical coherence tomography (SD-OCT and SS-OCT) are the standard-of-care in daily clinical practice, adding detailed quantitative microstructural information during preoperative evaluation, with multiple parameters, some with post-operative prognostic value [13,14].

In addition, optical coherence tomography angiography (OCT-A), aims to further clarify microvascular elements in order to define the pathogenesis of the disease. Quantitative and qualitative OCTA metrics allow to analyse retinal and choroidal alterations induced by RRD [15,16]. Moreover, adaptive optics OCT (AO-OCT) provides more detailed data regarding disrupted cytoarchitecture of photoreceptors in preoperative and postoperative setting, useful in defining functional prognosis [17].

Other innovative imaging modalities such as ultra widefield imaging including optical coherence tomography (UWF-OCT) with the assistance of artificial intelligence may guide surgical planning and functional prognosis in the clinical setting. In this review of the literature, we aim to analyze and summarize all advantages and limitations of advanced preoperative imaging in macula-OFF RDD.

## 2. Materials and Methods: Search Strategy Design

We explore recent medical literature utilizing Pubmed, Google Scholar, Scopus, searching significative studies that address advanced imaging techniques employed to evaluate RRD, focusing on “macula-off” RRD. Keywords searched were combined to find significative articles that employed modern imaging modalities to analyze macula off-RRD. Researched words were “SD-OCT”, “SS-OCT”, “OCT-angiography”, “ultra widefield OCT” “adaptive optics-OCT”, “preoperative imaging in RD” and “artificial intelligence in RD”. We excluded other forms of RD and other imaging modalities in our analysis. We include case-series, retrospective, prospective studies, randomized clinical trials and meta-analysis.

### 3. Advanced Imaging Techniques in the Preoperative Evaluation of Macula-Off RRD

#### 3.1. Spectral-Domain OCT and Swept-Source OCT

SD-OCT is a high resolution, non-invasive medical imaging technique with increased axial resolution and high scan speed that capture cross-sectional images of the retina, improving sensitivity and specificity of microstructure analysis [13,14]. Whereas SS-OCT gain deeper penetration of analysis, providing histological-like, single-layer definition of retina morphology. [13,14]. Both strategies are employed in pre-operating evaluation of RD and some studies emphasize the role of these imaging tools to define a classification of RRD, considering the macula and fovea status, that is one of predictive factor of postoperative visual functions [13,14].

In particular Klaas et al. develop a potential classification, defining five grades (G1-G5) of macula involving (MIRD) and central involving retinal detachment (CIRD), adhering to the original ETDRS nomenclature [18]. If CIRD was limited to three outer ETDRS quadrants (G4), mean BCVA was better compared to CIRD involving all four ETDRS quadrants (G5). Multivariate regression analysis demonstrates that lower grade of detachment and lower extent of cystoid edema were both associated with better postoperative function [18]. These results are in line with other studies and correlates with disruption of outer retinal layers and alternated photoreceptor functionality [19,20]. However, Poulsen et al. in a prospective study that includes macula-off RD, reported that eyes with less microstructural alterations were associated with better visual outcomes in comparison with eyes with macular detachment with altered intraretinal appearance [21].

As a support Mané and colleagues reporting data from preoperative SD-OCT, demonstrating that a shallow RD involving the foveal center in macula-off RD had similar functional results to macula on RD, probably due to preoperative reduced duration of RD and moderate loss of visual acuity [22].

However, there are other factors like age, onset and duration of the symptoms, timing of surgical RD repair, surgical technique employed and quality of surgical abilities that play a role in functional outcomes. In particular, baseline visual acuity and timing to surgery are considered good predictors of visual outcomes, as demonstrated by Felfeli et al. and Chatziralli et al [23,24]. In detail, low visual acuity at baseline is associated with poorer postoperative functional outcomes and delayed surgery is associated with alterations in outer retinal and photoreceptor functionality [23,24].

#### OCT-Derived Potential Biomarkers

In clinical management of macula-off RD, multiple studies tried to search emerging parameters from SD-OCT and SS-OCT in preoperative setting that may have a prognostic role, predicting visual function recovery [25]. OCT biomarkers are summarized in Table 1. Some studies explored quantitative assessment of subretinal fluid volume and subsequently the height of retinal detachment (HRD) at the level of the fovea. [18,26]

**Table 1.** Optical coherence tomography imaging features and functional correlations.

Imaging feature	Imaging modality	Prognostic consequences
Height of retinal detachment (HRD)	SD-OCT/SS-OCT	Higher vertical foveal-RPE distance of the detached retina, may be weakly correlated with worse functional outcomes.
Retinal thickness and central macular thickness	SD-OCT/SS-OCT	Variable functional outcomes and no clinical correlation in literature, longer studies are needed.
Subretinal Hyperreflective points (HRPs)	SD-OCT/SS-OCT	Independent predictive value of HRPs on

		postoperative visual prognosis is still debated; a possible negative functional correlation.
<b>Intraretinal cystic cavities (ICCs)</b>	SD-OCT/SS-OCT	Focal ICCs may have slight effect on functional recovery, however extensive involvement seems predicting worse VA.
<b>EZ and ELM integrity and relevance EZ reflectivity (rEZR)</b>	SD-OCT/SS-OCT	Discontinuity of EZ/ELM and alteration in EZ reflectivity (rEZR) is correlated with worse functional outcomes, while integrity of both are associated with better VA.
<b>Outer retinal corrugations (ORCs) and undulations (ORUs)</b>	SD-OCT/SS-OCT	Evidence of ORCs may be associated with worse anatomical and functional outcomes; while the predictive value of ORUs is still debated.
<b>Outer Retinal Folds (ORFs)</b>	SD-OCT/SS-OCT	The Onset of ORFs after surgery is associated with metamorphopsia
<b>Bacillary Layer Detachment (BALAD)</b>	SD-OCT/SS-OCT	The onset of BALAD is associated with an increased risk of full thickness macular hole after surgery

This biomarker has been reported by different studies as a potential predictor of postoperative visual function: higher foveal detachment height was correlated with low preoperative and postoperative functional outcomes [18,25,26]. However, a recent meta-analysis by Murtaza et al. found weak correlation between HRD and postoperative visual function [27].

Differently, other studies have analyzed a possible association between retinal thickness (RT) and postoperative visual function [18,19,28]. In particular, regarding central macular thickness (CMT), there is not a clear relationship with postoperative visual acuity and further studies are needed to address this topic. However, Gharbiya et al. described a statistically significant relationship between outer nuclear layer (ONL) thickness and BCVA [29]. It was shown that eyes with photoreceptor layer disruption  $\geq 200 \mu\text{m}$  had a significantly worse postoperative BCVA than those with less extensive disruption  $< 200 \mu\text{m}$ . [29]

Subretinal hyper-reflective points (HRPs) detected on OCT may represent inflammatory response by intraretinal cells or aggregates related to retinal injury.

In a retrospective study by Savastano et al. HRPs have been postulated to have a negatively impact on postoperative visual function together with foveal detachment, however the independent predictive value of HRPs on postoperative visual prognosis is still debated and further research is needed [30].

Similarly, Russell and colleagues reported in RD case-series the evidence on OCT of HRPs in the ellipsoid/interdigitation layers, that may help dating the RD and understand the distribution of the subretinal fluid and subsequently localize retinal breaks [31].

Intraretinal cystic cavities (ICCs) described in different studies in macula-off RD eyes are often associated with poorer prognosis, possibly indicating more severe retinal layer disruption.

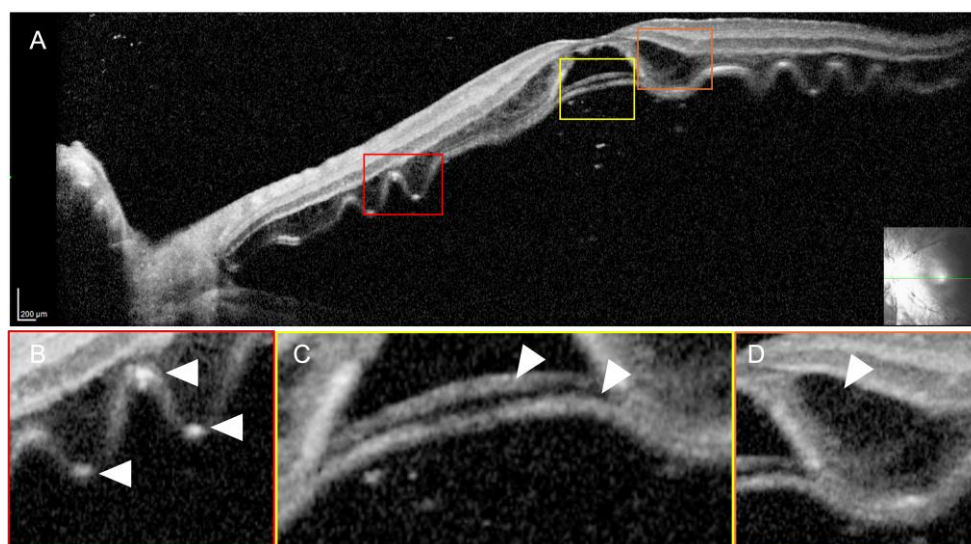
Preoperative ICCs extended in multiple retinal layers are associated with poor postoperative visual acuity due to diffuse alterations and disruption of blood-retinal barrier. Localized ICCs are not significantly correlated with postoperative visual acuity [27].

Moreover, the integrity of ellipsoid zone (EZ) and external limiting membrane (ELM) has been recognized as predictor of postoperative visual function. Eyes with preoperative continuity of EZ and ELM has significantly better postoperative visual acuity [32]. Guan et al reported that discontinuity of EZ was significantly associated with worse postoperative visual acuity [28]. Similarly, a recent study by Sassen et al, supports the relevance of EZ reflectivity (rEZR), a novel SD-OCT imaging biomarker for photoreceptor integrity; higher rEZR values were significantly associated with better BCVA and scleral buckling [33]. Moreover, a retrospective study by Vidal Olivier et al., supports the value of rEZR as a biomarker of photoreceptors metabolic recovery and alterations in EZ and ELM are correlated with poor visual recovery [34].

Moreover, very recently bacillary layer detachment (BALAD) has been found in about one-fourth of cases with macula OFF RRD. [35] BALAD has been defined as a characteristic intraphotoreceptor separation within the myoid zone, appearing on OCT as hyporeflective space beneath the ELM. Its onset has been attributed to tractional forces on the outer retina. [36] The presence of BALAD in macula off RRD has been associated with poor visual outcome after surgery and an increased risk of full thickness macular hole after surgery. [35,36]

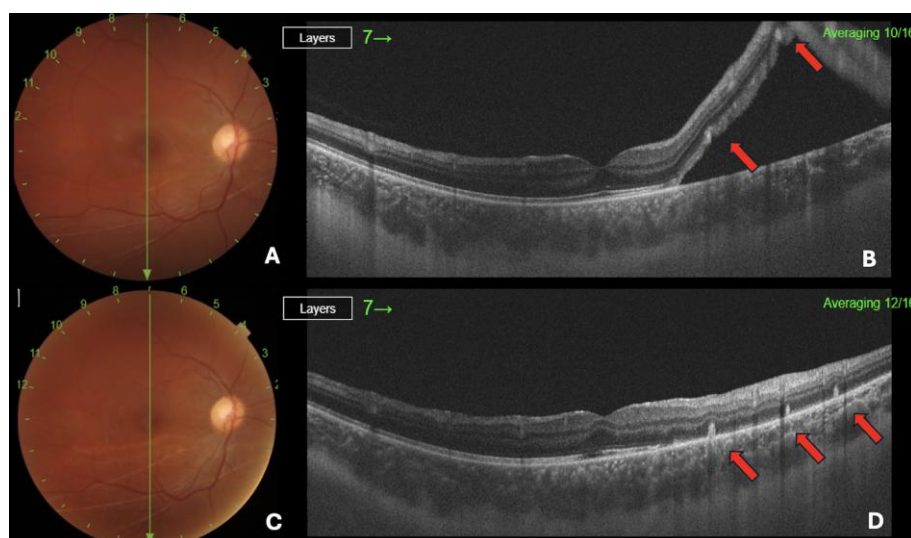
Some authors investigated the role of outer retinal corrugations (ORCs), defined as multiple, consecutive high-frequency undulations evident at the level of the outer retina. The study of Nagpal and colleagues ORCs were associated with poor post-operative visual outcomes; [37] in other studies, this parameter was associated with alteration of reflectivity in photoreceptors layer and the EZ [4,14,38]. It is debated if ORCs are the precursor of outer retinal folds observed in postoperative follow-up. [35]

In Figure 1 are shown several OCT biomarkers including ORCs, BALAD and ICC.



**Figure 1.** Spectral domain optical coherence tomography Bscan of a macula OFF retinal detachment (A) showing outer retina corrugations (red square B), bacillary layer detachment (yellow square C), intraretinal cysts cavities (orange square D).

Besides ORCs, outer retinal undulations (ORUs) are a debated biomarker, described in the retrospective study by Yeo et al [39]. They may correlate with the duration of the RD: in particular, younger patients and early RD had higher incidence of outer retinal undulations, but there was a statistical significant relationship with postoperative visual outcomes [19]. Postoperative outer retinal folds (ORFs) have recently been considered an important anatomic factor affecting visual function in RRD surgery. ORFs appear on OCT scans as small hyperreflective lesions extending obliquely or vertically into the outer nuclear layer (Figure 2).



**Figure 3. A-B. Color fundus picture (CFP) and swept source optical coherence tomography (SS-OCT) of preoperative inferior retinal detachment. Red arrows showing the outer retinal folds (ORFs). C-D. CFP and SS-OCT after pars plana vitrectomy showing a reattached retina with persisting ORFs.**

The onset of ORFs has been reported to range between 34% and 42% after PPV and although they have not a negative impact on postoperative VA, ORFs are associated with metamorphopsia [40,41].

OCT features furthermore may be implemented and apply with other purposes: Martins Melo and colleagues proposed an innovative RRD staging system based on different imaging features accessed with SS-OCT [42]:

- stage 1: separation of the neurosensory retina from the RPE;
- stage 2: thickening of the photoreceptor layer;
- stage 3: formation of ORC, divided in:
  - 3a: low frequency ORCs
  - 3b: high frequency ORCs;
- stage 4: progressive loss of ORC definition with concurrent thickening of the photoreceptor layer;
- stage 5: partly (“moth-eaten”) or complete loss of photoreceptors.

All OCT features and their prognostic consequences are summarized in Table 1.

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2. stage 2: thickening of the photoreceptor layer;
3. stage 3: formation of ORC, divided in:
  - 3a: low frequency ORCs
  - 3b: high frequency ORCs;
4. stage 4: progressive loss of ORC definition with concurrent thickening of the photoreceptor layer;
5. stage 5: partly (“moth-eaten”) or complete loss of photoreceptors. [42]

SD-OCT and SS-OCT are useful imaging techniques in clinical management of macula-off RD and multiple parameters and biomarkers may have a prognostic value; however, surgical factors influence the evolution and the impact of these biomarkers in successful functional outcomes. More studies are needed to further clarify these topics.

### 3.2. OCT Angiography

OCT-A is an innovative imaging tool based on the principle of diffractive particles motion detection delineating retinal and choroidal vascularization that may be employed in the study of numerous retinal diseases. [43] In multimodal imaging perspective this modality acts as an adjunctive imaging technique next to conventional dye angiography. Numerous parameters and metrics are discovered, like foveal avascular zone (FAZ), foveal and parafoveal vessel density (VD) of retinal plexuses and others applied to study pathophysiological information in multiple retinal and choroidal disorders, like diabetic retinopathy, age-related macular degeneration, even in RD [44,45].

Its role in the preoperative management of macula-off RD has to be defined and the use of this tool in macula-off RD is challenging due to motion artifacts, media opacities, segmentation errors. Several studies report changes in some OCT-A parameters (FAZ area, capillary density) after surgical repair, but a clear relationship with postoperative visual function and the predictive role of these biomarkers on visual prognosis are lacking [44–46]. Some authors found an increase of the FAZ and a reduction in VD, in superficial and/or deep capillary plexuses with heterogeneous results, in eyes undergoing RD surgical repair, in comparison with normal eyes [45–49].

Despite this interesting data, further studies investigating the role of OCT-A in macula-off RD are needed, defining preoperative biomarkers or microvascular changes with a significant predictive prognostic value and aiding precise surgical decisions for every patient.

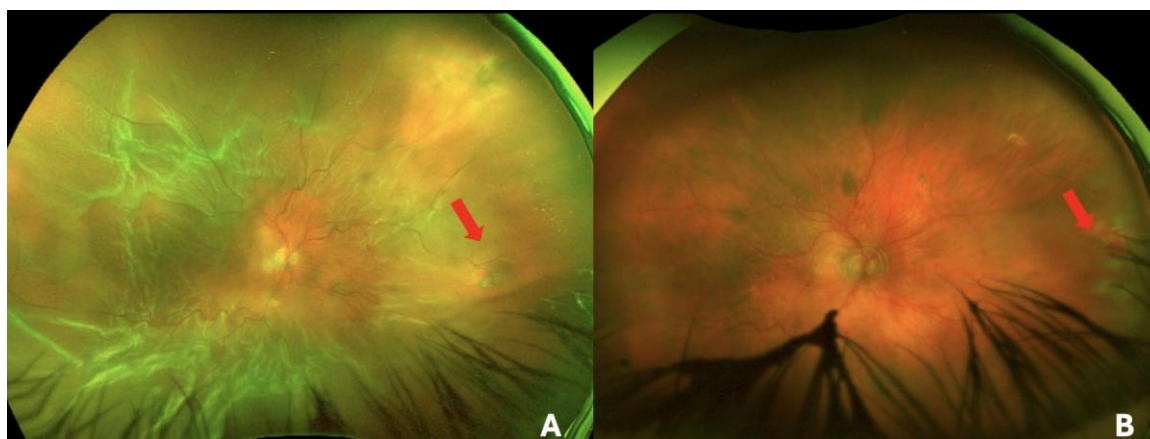
### 3.3. Ultra-Widefield Color fundus picture and Fundus Autofluorescence

Ultra-widefield (UWF) color fundus photography has significantly expanded the ability to document and evaluate peripheral retinal pathology compared with conventional 30°-50° imaging systems. By capturing up to 200° of the retina in a single image, UWF imaging allows improved visualization of the periphery, facilitating detection of various retinal conditions, such as in our case, the full extent of RRD, which may influence surgical planning and management decisions [50].

Clinical studies have demonstrated that UWF imaging enhances identification of peripheral lesions that may be missed on standard photography, thereby improving diagnostic sensitivity and documentation in both medical and surgical retina practice [51]. Additionally, UWF systems provide rapid, noncontact acquisition, which is particularly advantageous in patients with limited cooperation or media opacity. However, there are limitations, including peripheral image distortion due to the curved retinal surface and variable magnification toward the edges of the image, which may affect lesion size estimation and localization [52]. Despite these constraints, UWF color photography represents a valuable adjunct to dilated fundus examination and multimodal imaging, contributing to comprehensive assessment of peripheral retinal disease.

A study by Zuk et al shows that traditional peripheral retinal evaluation with dilated examination or ultra-widefield color photography lacks cross-sectional detail of vitreoretinal and microstructural changes.[53] They combined UWF imaging with swept-source OCT to improve visualization and characterization of peripheral lesions. Even though optical artifacts and reduced sensitivity in far anterior regions remain some limits, this technique might be taken into consideration and studied more. [53]

A study by Nadelmann and colleagues reports the use of Ultra Widefield Autofluorescence (UWA) in the differential diagnosis of RD and retinoschisis (RS): on UWF eyes with RD appear bullous with hyperreflective leading edge and homogenous pattern in comparison with eyes with RS, conferring to this imaging tool an adjunctive and complementary utility in clinical assessment [54].



**Figure 4.** Ultrawidefield fundus picture (UWFP) images of a patient with total rhegmatogenous retinal detachment (RRD). (A) Preoperative UWFP assessment clearly showing the extension of the RD in all quadrants and the retinal break in the temporal nasal field. (B) Postoperative UWFP showing a flat retina with laser scars surrounding the nasal retinal break and silicon oil in the vitreous chamber.

### 3.4. Ultra-Widefield OCT

With continuous implementing of imaging technology, emerging use of UWF-OCT through cross-sectional scan imaging of the entire retina, up to the peripheral retina, led clinicians obtaining detailed images between 110-200° of view, from the anterior border of vortex vein ampulla to the ora serrata, as described in the international widefield imaging study group [55].

This imaging modality is useful in clinical diagnosis and monitoring of numerous retinal diseases, including RRD. Multiple studies have demonstrated the enhanced diagnostic capability of UWF-OCT in detecting subtle peripheral retinal lesions [56–58]. In a large cohort study by the application of UWF-OCT revealed previously undetected significant peripheral lesions in 39% of cases, 31% of which not identified with conventional OCT and slit-lamp examination; moreover in the same study UWF-OCT aid localizing retinal detachment, the extension and related characteristics, demonstrating its useful role in the clinical assessment of RD [59].

Other studies show that UWF-OCT provides significant anatomical information, helping clinicians in differential diagnosis with other pathological entities, directly influencing management decisions and treatment strategies [60–62].

Recently in a cross-sectional study, Agarwal et al. expanded the detection of peripheral retinal lesions with UFW-OCT, predisposing and not-predisposing to RRD, providing information regarding tractional vitreous and suspected areas, helping clinicians in their management decisions [63]. Despite the high cost, limits of the techniques, motion artifacts, poor pupillary mydriasis and limits, UWF-OCT is a valuable and emerging tool that may guide routinely clinical management of macula-off RD, influencing the surgical planning and functional prognosis.

### 3.5. Emerging Imaging Techniques

#### Adaptive Optics OCT

AO in ophthalmology is applied to limit chromatic aberrations to obtain high resolution images and studying in vivo detailed tissues microstructure, in particular photoreceptor cytoarchitecture and fine cellular elements, with an axial resolution of 2  $\mu\text{m}$  [17,64,65]. Some authors assessed microstructural changes in vivo eyes affected by macula-off RD reporting an entire disruption of retinal layers architecture, distortion of cone mosaic and alteration in cone density [66]. In a prospective study, Reumueller et al. AO-OCT was utilized in macula-off RDs underwent surgical repair. [66] During postoperative imaging evidence of cone mosaic distortion was reported, even with visual improvement [66].

Newly there is evidence of changes in reflectivity of the EZ of photoreceptors, as demonstrated by Sassen et al. and sustained by Vidal-Oliver and colleagues, which may aid to augment knowledge in anatomical and functional recovery of photoreceptors in the context of RRD [33,34].

To date, there is not literature regarding the clinical applications of AO-OCT in preoperative management of macula-off RD, due to high-cost technologies, long duration of examination, artifacts and the nature of the pathology. Besides, AO-OCT is an innovative tool to monitor the postoperative functional recovery and it may help in understanding the pathophysiology of RD and metabolic changes in retinal cellular elements in a possible blindness-leading condition as macula-off RRD.

### 3.6. Artificial Intelligence

AI is revolutionizing the clinical management of RRD by improving diagnostic accuracy, guiding preoperative decision-making, and potentially optimizing treatment outcomes [67].

AI models employing UWF-fundus photography and OCT have been engineered to detect RD and differentiate macula status preoperatively. [67,68]

Li et al developed a pioneering deep learning system using over 24,000 UWF fundus images that achieved precision to localizing retinal detachment areas [68]. Similarly, Wang and colleagues report a deep learning model trained with 6000 ultrasound images achieved a AOC of 0.998 with a sensitivity of 99.2% and a specificity of 99.8%, encouraging the role of this AI-tool in support ophthalmologists' clinical diagnosis [69]. The potential advantages of deep learning models in predicting the anatomical outcomes of RRD surgery was further investigated [69–72].

Beyond detection, AI assists in anatomical and functional prognosis by integrating imaging biomarkers with clinical variables to predict postoperative visual outcomes after RRD repair. Deep learning fusion models combining UWF fundus images and OCT scans have predicted visual acuity outcomes with high accuracy [73,74].

Although AI systems do not replace retinal specialist expertise, they may serve as decision-support tools that liberate clinicians' capacity to focus on personalized care and complex cases while improving timely treatment access.

## 4. Conclusions

Advanced imaging modalities in ophthalmology have revolutionized the clinical assessment of numerous retinal conditions, including macula-off RRD. Hence, the widespread use of SD-OCT and SS-OCT in different vitreoretinal disorders enhanced the knowledge of pathophysiology of macula-off RRD, discovering multiple promising OCT parameters like: HRD, RT, ICCs, ORCs, ORUs, ORFs, HRP, EZ/ELM disruption and rEZR, which may have a predictive value in functional prognosis.

Moreover, OCT-A is an interesting and emerging imaging tool which provide information about retinal and choroidal vasculature, while its role in preoperative assessment of macula-off RD is still debated, due to artifacts and limitations of the pathology itself. Microvascular OCT-A parameters, like VD and FAZ increase after surgery could provide additional information regarding the retinal and choroidal recovery in postoperative setting.

Additionally, AO-OCT may be a complementary and adjunctive advanced diagnostic modality playing a role in photoreceptors anatomy and functionality especially in research field. Nevertheless, its employing in daily clinical practice is not routine.

UWF-color, FAF and OCT are useful imaging tools that adjuvate clinicians in clinical diagnosis, with a non-invasive approach, allowing an overall perspective, especially useful in management of macula off- RDD. Furthermore, UWF imaging validity is promising in treatment planning, influencing the technical and surgical decisions.

Emerging diffusion of AI and deep-learning models in clinical ophthalmology are propitious instruments that may have significant impact on clinical evaluation of multiple retinal conditions, enhancing accuracy and efficacy in diagnosis together with prognostic values.

It is crucial to comprehend the limits, legal and ethical issues of these innovative tools in modern medicine practice. Further research is needed to better assess and manage macula-off RRD, a

potential vision-threatening disease. Application of multimodal imaging with development of deep learning models may significantly help vitreoretinal surgeons in daily work for either diagnostic and therapeutic purposes.

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## References

1. D. Mitry, D. G. Charteris, B. W. Fleck, H. Campbell, e J. Singh, «The epidemiology of rhegmatogenous retinal detachment: geographical variation and clinical associations», *Br J Ophthalmol*, vol. 94, fasc. 6, pp. 678–684, giu. 2010, doi: 10.1136/bjo.2009.157727.
2. J. Y. Ge et al., «International incidence and temporal trends for rhegmatogenous retinal detachment: A systematic review and meta-analysis», *Surv Ophthalmol*, vol. 69, fasc. 3, pp. 330–336, 2024, doi: 10.1016/j.survophthal.2023.11.005.
3. N. G. Ghazi e W. R. Green, «Pathology and pathogenesis of retinal detachment», *Eye (Lond)*, vol. 16, fasc. 4, pp. 411–421, lug. 2002, doi: 10.1038/sj.eye.6700197.
4. P. L. Oquendo et al., «Optical Coherence Tomography Features in Fovea-Off Exudative vs Rhegmatogenous Retinal Detachment», *American Journal of Ophthalmology*, vol. 268, pp. 212–221, dic. 2024, doi: 10.1016/j.ajo.2024.07.003.
5. C. Mishra e K. Tripathy, «Retinal Traction Detachment», in *StatPearls*, Treasure Island (FL): StatPearls Publishing, 2025. Consulted: 5th September 2025. [Online]. Available on: <http://www.ncbi.nlm.nih.gov/books/NBK558952/>
6. E. M. van Bussel, R. van der Valk, W. R. Bijlsma, e E. C. La Heij, «Impact of duration of macula off retinal detachment on visual outcome: a systematic review and meta-analysis of literature», *Retina*, vol. 34, fasc. 10, pp. 1917–1925, ott. 2014, doi: 10.1097/IAE.000000000000296.
7. C. S. Lee, K. Shaver, S. H. Yun, D. Kim, S. Wen, e G. Ghorayeb, «Comparison of the visual outcome between macula-on and macula-off rhegmatogenous retinal detachment based on the duration of macular detachment», *BMJ Open Ophthalmol*, vol. 6, fasc. 1, p. e000615, mar. 2021, doi: 10.1136/bmjophth-2020-000615.
9. J. Xiong, T. Tran, S. M. Waldstein, e A. T. Fung, «A review of rhegmatogenous retinal detachment: past, present and future», *Wien Med Wochenschr*, vol. 175, fasc. 7, pp. 186–202, mag. 2025, doi: 10.1007/s10354-025-01085-9.
10. D. Yorston, P. H. J. Donachie, D. A. Laidlaw, D. H. Steel, T. H. Williamson, e members of the Britain & Eire Association of Vitreoretinal surgeons (BEAVRS) and Euretina Retinal Detachment Study Groups, «Predicting post-surgery change in visual acuity after successful repair of macula-off retinal detachments: findings from a large prospective UK cohort study», *Eye (Lond)*, vol. 39, fasc. 11, pp. 2298–2306, ago. 2025, doi: 10.1038/s41433-025-03752-y.
11. G. Chereji, O. Samoilă, e S. D. Nicoară, «Prognostic Factors for Visual Postsurgical Outcome in Rhegmatogenous Retinal Detachment—A Systematic Review», *Journal of Clinical Medicine*, vol. 14, fasc. 6, p. 2016, gen. 2025, doi: 10.3390/jcm14062016.
12. H. J. Ng, K. A. Vermeer, E. C. La Heij, C. P. Kuip, e J. C. van Meurs, «Retinal damage extends beyond the border of the detached retina in fovea-on retinal detachment», *Acta Ophthalmologica*, vol. 102, fasc. 3, pp. 285–295, 2024, doi: 10.1111/aos.15713.

13. A. Sothivannan et al., «Impact of the Time to Surgery on Visual Outcomes for Rhegmatogenous Retinal Detachment Repair: A Meta-Analysis», *Am J Ophthalmol*, vol. 244, pp. 19–29, dic. 2022, doi: 10.1016/j.ajo.2022.07.022.
14. R. Angermann, N. E. Bechrakis, T. Rauchegger, M. Casazza, Y. Nowosielski, e C. Zehetner, «Effect of Timing on Visual Outcomes in Fovea-Involving Retinal Detachments Verified by SD OCT», *J Ophthalmol*, vol. 2020, p. 2307935, 2020, doi: 10.1155/2020/2307935.
15. I. Martins Melo et al., «Morphologic Stages of Rhegmatogenous Retinal Detachment Assessed Using Swept-Source OCT», *Ophthalmol Retina*, vol. 7, fasc. 5, pp. 398–405, mag. 2023, doi: 10.1016/j.oret.2022.11.013.
16. F. Barca et al., «OCT Angiography Findings in Macula-ON and Macula-OFF Rhegmatogenous Retinal Detachment: A Prospective Study», *Journal of Clinical Medicine*, vol. 9, fasc. 12, p. 3982, dic. 2020, doi: 10.3390/jcm9123982.
17. P. Díaz-Aljaro et al., «Quantitative Microvascular Change Analysis Using a Semi-Automated Software in Macula-off Rhegmatogenous Retinal Detachment Assessed by Swept-Source Optical Coherence Tomography Angiography», *Journal of Clinical Medicine*, vol. 13, fasc. 10, p. 2835, gen. 2024, doi: 10.3390/jcm13102835.
18. M. Balas, V. Ramalingam, B. Pandya, A. Abdelaal, e R. B. Shi, «Adaptive optics imaging in ophthalmology: Redefining vision research and clinical practice», *JFO Open Ophthalmology*, vol. 7, p. 100116, set. 2024, doi: 10.1016/j.jfop.2024.100116.
19. J. E. Klaas et al., «Functional recovery after macula involving retinal detachment and its correlation with preoperative biomarkers in optical coherence tomography», *Graefes Arch Clin Exp Ophthalmol*, vol. 259, fasc. 9, pp. 2521–2531, 2021, doi: 10.1007/s00417-021-05113-3.
20. Y. D. Yeo e Y. C. Kim, «Significance of outer retinal undulation on preoperative optical coherence tomography in rhegmatogenous retinal detachment», *Sci Rep*, vol. 10, fasc. 1, p. 15747, set. 2020, doi: 10.1038/s41598-020-72907-6.
21. M. Mete, E. Maggio, F. Ramanzini, M. Guerriero, G. Airaghi, e G. Pertile, «Microstructural Macular Changes after Pars Plana Vitrectomy for Primary Rhegmatogenous Retinal Detachment», *Ophthalmologica*, vol. 244, fasc. 6, pp. 551–559, 2021, doi: 10.1159/000517880.
22. C. D. Poulsen, M. P. Petersen, A. Green, T. Peto, e J. Grauslund, «Fundus autofluorescence and spectral domain optical coherence tomography as predictors for long-term functional outcome in rhegmatogenous retinal detachment», *Graefes Arch Clin Exp Ophthalmol*, vol. 257, fasc. 4, pp. 715–723, apr. 2019, doi: 10.1007/s00417-018-04222-w.
24. V. Mané et al., «Preoperative Optical Coherence Tomography Findings of Foveal-Splitting Rhegmatogenous Retinal Detachment», *Ophthalmologica*, vol. 244, fasc. 2, pp. 127–132, 2021, doi: 10.1159/000510726.
25. I. Chatziralli et al., «Predictive Factors for Long-Term Postoperative Visual Outcome in Patients with Macula-Off Rhegmatogenous Retinal Detachment Treated with Vitrectomy», *Ophthalmologica*, vol. 244, fasc. 3, pp. 213–217, 2021, doi: 10.1159/000514538.
26. T. Felfeli, F. Murtaza, B. Abueh, M. S. Mandelcorn, D. D. Wong, e E. D. Mandelcorn, «Clinical Significance of Macula-Off Rhegmatogenous Retinal Detachment Preoperative Features on Optical Coherence Tomography», *Ophthalmic Surg Lasers Imaging Retina*, vol. 52, fasc. S1, pp. S23–S29, lug. 2021, doi: 10.3928/23258160-20210518-05.
27. R. Angermann et al., «Impact of submacular fluid volume on visual outcome in macula-off rhegmatogenous retinal detachment using automated optical coherence tomography volumetric quantification», *Clin Exp Ophthalmol*, vol. 49, fasc. 5, pp. 439–447, lug. 2021, doi: 10.1111/ceo.13929.
28. C. Baumann, A. Almarzooqi, N. Johannigmann-Malek, M. Maier, e S. Kaye, «Importance of subfoveal fluid height on visual outcome in macula-off retinal detachments», *Br J Ophthalmol*, p. bjophthalmol-2022-321604, lug. 2022, doi: 10.1136/bjo-2022-321604.
29. F. Murtaza et al., «Prognostic Features of Preoperative OCT in Retinal Detachments: A Systematic Review and Meta-analysis», *Ophthalmol Retina*, vol. 7, fasc. 5, pp. 383–397, mag. 2023, doi: 10.1016/j.oret.2022.11.011.

30. I. Guan et al., «ROLE OF OPTICAL COHERENCE TOMOGRAPHY FOR PREDICTING POSTOPERATIVE VISUAL OUTCOMES AFTER REPAIR OF MACULA-OFF RHEGMATOGENOUS RETINAL DETACHMENT», *Retina*, vol. 41, fasc. 10, pp. 2017–2025, ott. 2021, doi: 10.1097/IAE.0000000000003162.
31. M. Gharbiya et al., «Correlation between spectral-domain optical coherence tomography findings and visual outcome after primary rhegmatogenous retinal detachment repair», *Retina*, vol. 32, fasc. 1, pp. 43–53, gen. 2012, doi: 10.1097/IAE.0b013e3182180114.
32. M. C. Savastano et al., «OCT analysis of preoperative foveal microstructure in recent-onset macula-off rhegmatogenous retinal detachment: visual acuity prognostic factors», *Br J Ophthalmol*, vol. 108, fasc. 12, pp. 1743–1748, nov. 2024, doi: 10.1136/bjo-2024-325278.
33. J. F. Russell, «Whitish Outer Retinal Spots in Retinal Detachment: Longitudinal Follow-up, Multimodal Imaging, and Clinical Utility», *Ophthalmol Retina*, vol. 6, fasc. 6, pp. 469–477, giu. 2022, doi: 10.1016/j.oret.2022.01.017.
34. H. Noda et al., «RELATIONSHIP BETWEEN PREOPERATIVE FOVEAL MICROSTRUCTURE AND VISUAL ACUITY IN MACULA-OFF RHEGMATOGENOUS RETINAL DETACHMENT: Imaging Analysis by Swept Source Optical Coherence Tomography», *Retina*, vol. 40, fasc. 10, pp. 1873–1880, ott. 2020, doi: 10.1097/IAE.0000000000002687.
35. S. H. Sassen et al., «Early Photoreceptor Alterations After Retinal Detachment Repair», *Invest Ophthalmol Vis Sci*, vol. 66, fasc. 9, p. 32, lug. 2025, doi: 10.1167/iovs.66.9.32.
36. L. Vidal-Oliver et al., «Early photoreceptor assessment as a predictor for visual acuity gain after vitrectomy for macula-off retinal detachment», *Int J Retina Vitreous*, vol. 11, fasc. 1, p. 95, ago. 2025, doi: 10.1186/s40942-025-00722-0.
37. Prognostic factors after rhegmatogenous retinal detachment repair: An overview of the clinical and imaging insights Antonio La Rosa, MD Alessandro Feo, MD Andrea Govetto, MD PhD Tommaso Rossi, MD Mario R. Romano, MDPhD <https://www.surveyoophthalmol.com/article/S0039-6257%2826%2900002-0/fulltext>
38. Venkatesh, Ramesh MS1; Raj, Pragati MS1; Tripathi, Shubhangi MS1; Prabhu, Vishma MS1; Hande, Pratibha MS1; Kalshetty, Akshata MS1; Jayadev, Chaitra MS1; Pai, Madhav MS1; Malwe, Gaurav MS1; Yadav, Naresh Kumar DO1. Bacillary Layer Detachment in Primary Rhegmatogenous Retinal Detachment: Occurrence, Predictors, and Surgical Outcomes. *Retina* ( ):10.1097/IAE.0000000000004784, January 20, 2026. | DOI: 10.1097/IAE.0000000000004784
39. M. Nagpal et al., «Morphometric analysis of fovea with spectral-domain optical coherence tomography and visual outcome postsurgery for retinal detachment», *Indian J Ophthalmol*, vol. 62, fasc. 8, pp. 846–850, ago. 2014, doi: 10.4103/0301-4738.141037.
40. R. H. Muni et al., «Outer Retinal Corrugations in Rhegmatogenous Retinal Detachment: The Retinal Pigment Epithelium-Photoreceptor Dysregulation Theory», *Am J Ophthalmol*, vol. 245, pp. 14–24, gen. 2023, doi: 10.1016/j.ajo.2022.08.019.
41. Yeo YD, Kim YC. Significance of outer retinal undulation on preoperative optical coherence tomography in rhegmatogenous retinal detachment. *Sci Rep*. 2020 Sep 25;10(1):15747. doi: 10.1038/s41598-020-72907-6. PMID: 32978493; PMCID: PMC7519122.
42. Lee WW, Bansal A, Sadda SR, et al. Outer retinal folds after pars plana vitrectomy vs. pneumatic retinopexy for retinal detachment repair: post hoc analysis from PIVOT. *Ophthalmol Retina*. 2022;6(3):234-242.
43. 2022;6(3):234-242.
44. Peiretti E, Nasini F, Buschini E, et al. Optical coherence tomography evaluation of patients with macula-off retinal detachment after different postoperative posturing: a randomized pilot study. *Acta Ophthalmol*. 2017;95(5):e379-e384.
45. I. Martins Melo et al., «Impact of Baseline Morphologic Stage of Rhegmatogenous Retinal Detachment on Postoperative Visual Acuity», *Ophthalmol Retina*, vol. 8, fasc. 7, pp. 624–632, lug. 2024, doi: 10.1016/j.oret.2024.01.014.
46. de Carlo TE, Romano A, Waheed NK, Duker JS. A review of optical coherence tomography angiography (OCTA). *Int J Retina Vitreous*. 2015 Apr 15;1:5. doi: 10.1186/s40942-015-0005-8. PMID: 27847598; PMCID: PMC5066513.

47. E. Custo Greig et al., «Macular and Peripapillary Optical Coherence Tomography Angiography Metrics Predict Progression in Diabetic Retinopathy: A Sub-analysis of TIME-2b Study Data», *Am J Ophthalmol*, vol. 219, pp. 66–76, nov. 2020, doi: 10.1016/j.ajo.2020.06.009.
48. B. Zhang, Y. Chou, X. Zhao, J. Yang, e Y. Chen, «Early Detection of Microvascular Impairments With Optical Coherence Tomography Angiography in Diabetic Patients Without Clinical Retinopathy: A Meta-analysis», *Am J Ophthalmol*, vol. 222, pp. 226–237, feb. 2021, doi: 10.1016/j.ajo.2020.09.032.
49. J. M. Woo, Y. S. Yoon, J. E. Woo, e J. K. Min, «Foveal Avascular Zone Area Changes Analyzed Using OCT Angiography after Successful Rhegmatogenous Retinal Detachment Repair», *Curr Eye Res*, vol. 43, fasc. 5, pp. 674–678, mag. 2018, doi: 10.1080/02713683.2018.1437922.
50. C.-L. Tsen, S.-J. Sheu, S.-C. Chen, e T.-T. Wu, «Imaging analysis with optical coherence tomography angiography after primary repair of macula-off rhegmatogenous retinal detachment», *Graefes Arch Clin Exp Ophthalmol*, vol. 257, fasc. 9, pp. 1847–1855, set. 2019, doi: 10.1007/s00417-019-04381-4.
51. H. Ng, E. C. La Heij, E.-R. Andrinopoulou, J. C. van Meurs, e K. A. Vermeer, «Smaller Foveal Avascular Zone in Deep Capillary Plexus Is Associated with Better Visual Acuity in Patients after Macula-off Retinal Detachment Surgery», *Transl Vis Sci Technol*, vol. 9, fasc. 10, p. 25, set. 2020, doi: 10.1167/tvst.9.10.25.
52. X. Chen, W. Li, X. Jin, Y. Zhang, R. Li, e T. Liu, «Macular microcirculation changes after repair of rhegmatogenous retinal detachment assessed with optical coherence tomography angiography: A systematic review and meta-analysis», *Front. Physiol.*, vol. 13, dic. 2022, doi: 10.3389/fphys.2022.995353.
54. Midená, E., Marchione, G., Di Giorgio, S. et al. Ultra-wide-field fundus photography compared to ophthalmoscopy in diagnosing and classifying major retinal diseases. *Sci Rep* 12, 19287 (2022). <https://doi.org/10.1038/s41598-022-23170-4>
55. Kornberg, D. L., Klufas, M. A., Yannuzzi, N. A., Orlin, A., D'Amico, D. J., & Kiss, S. (2016). Clinical Utility of Ultra-Widefield Imaging with the Optos Optomap Compared with Indirect Ophthalmoscopy in the Setting of Non-Traumatic Rhegmatogenous Retinal Detachment. *Seminars in Ophthalmology*, 31(5), 505–512. <https://doi.org/10.3109/08820538.2014.981551>
56. Matthew T. Witmer, Szilárd Kiss, Wide-field Imaging of the Retina, *Survey of Ophthalmology*, Volume 58, Issue 2, 2013, Pages 143-154, ISSN 0039-6257, <https://doi.org/10.1016/j.survophthal.2012.07.003>. (<https://www.sciencedirect.com/science/article/pii/S0039625712001713>)
57. Žuk J, Safranow K, Machalińska A. Clinical Utility of Ultra-Widefield Fundus Photography with SS-OCT Images in Justifying Prophylactic Laser Photocoagulation of Peripheral Retinal Lesions. *Bioengineering (Basel)*. 2025 Dec 16;12(12):1367. doi: 10.3390/bioengineering12121367. PMID: 41463663; PMCID: PMC12729268.
58. J. B. Nadelmann et al., «Ultra-Widefield Autofluorescence Imaging of Retinal Detachment Compared to Retinoschisis», *Ophthalmic Surg Lasers Imaging Retina*, vol. 50, fasc. 9, pp. 550– 556, set. 2019, doi: 10.3928/23258160-20190905-03.
59. N. Choudhry et al., «Classification and Guidelines for Widefield Imaging: Recommendations from the International Widefield Imaging Study Group», *Ophthalmol Retina*, vol. 3, fasc. 10, pp. 843–849, ott. 2019, doi: 10.1016/j.oret.2019.05.007.
60. K. Koh, R. Tuuminen, e S. Jeon, «Ultra-Widefield–Guided Swept-Source OCT Findings of Peripheral Vitreoretinal Abnormality in Young Myopes», *Ophthalmology*, vol. 131, fasc. 4, pp. 434–444, apr. 2024, doi: 10.1016/j.ophtha.2023.11.009.
61. S. K. Sodhi, J. Golding, C. Trimboli, e N. Choudhry, «Feasibility of peripheral OCT imaging using a novel integrated SLO ultra-widefield imaging swept-source OCT device», *Int Ophthalmol*, vol. 41, fasc. 8, pp. 2805–2815, ago. 2021, doi: 10.1007/s10792-021-01837-7.
62. N. Choudhry, J. Golding, M. W. Manry, e R. C. Rao, «Ultra-Widefield Steering-Based Spectral-Domain Optical Coherence Tomography Imaging of the Retinal Periphery», *Ophthalmology*, vol. 123, fasc. 6, pp. 1368–1374, giu. 2016, doi: 10.1016/j.ophtha.2016.01.045.
63. M. Ripa, L. Motta, T. Florit, J.-Y. Sahyoun, V. Matello, e B. Parolini, «The Role of Widefield and Ultra Widefield Optical Coherence Tomography in the Diagnosis and Management of Vitreoretinal Diseases», *Diagnostics (Basel)*, vol. 12, fasc. 9, p. 2247, set. 2022, doi: 10.3390/diagnostics12092247.

64. K. D. Kovacs et al., «Feasibility and Clinical Utility of Ultra-Widefield-Navigated Swept Source Optical Coherence Tomography Imaging», *J Vitreoretin Dis*, vol. 5, fasc. 5, pp. 396–404, 2021, doi: 10.1177/2474126421997335.
65. W. W. Lee e R. H. Muni, «Single-capture ultra-widefield guided swept-source optical coherence tomography in the management of rhegmatogenous retinal detachment and associated peripheral vitreoretinal pathology», *Br J Ophthalmol*, vol. 107, fasc. 9, pp. 1356–1362, set. 2023, doi: 10.1136/bjophthalmol-2021-320149.
66. P. E. Stanga, F. J. Valentín-Bravo, U. I. Reinstein, A. Saladino, A. Arrigo, e S. E. F. Stanga, «The role of ultra-widefield imaging with navigated central and peripheral cross-sectional and three-dimensional swept source optical coherence tomography in ophthalmology: Clinical applications», *Saudi J Ophthalmol*, vol. 38, fasc. 2, pp. 101–111, 2024, doi: 10.4103/sjopt.sjopt\_59\_24.
67. A. Agarwal et al., «Evaluation of peripheral retinal degenerations using ultra-widefield swept source optical coherence tomography», *Graefes Arch Clin Exp Ophthalmol*, vol. 263, fasc. 2, pp. 305–313, feb. 2025, doi: 10.1007/s00417-024-06593-9.
68. L. Liu et al., «Application of Adaptive Optics in Ophthalmology», *Photonics*, vol. 9, fasc. 5, p. 288, mag. 2022, doi: 10.3390/photonics9050288.
69. M. A. Vasilescu e M. L. Macovei, «The Perspective of Using Optical Coherence Tomography in Ophthalmology: Present and Future Applications», *Diagnostics*, vol. 15, fasc. 4, p. 402, gen. 2025, doi: 10.3390/diagnostics15040402.
70. A. Reumueller et al., «Morphologic and Functional Assessment of Photoreceptors After Macula-Off Retinal Detachment With Adaptive-Optics OCT and Microperimetry», *American Journal of Ophthalmology*, vol. 214, pp. 72–85, giu. 2020, doi: 10.1016/j.ajo.2019.12.015.
71. D. T. Hogarty, D. A. Mackey, e A. W. Hewitt, «Current state and future prospects of artificial intelligence in ophthalmology: a review», *Clin Exp Ophthalmol*, vol. 47, fasc. 1, pp. 128–139, gen. 2019, doi: 10.1111/ceo.13381.
72. H. Li, J. Cao, K. You, Y. Zhang, e J. Ye, «Artificial intelligence-assisted management of retinal detachment from ultra-widefield fundus images based on weakly-supervised approach», *Frontiers in Medicine*, vol. 11, p. 1326004, feb. 2024, doi: 10.3389/fmed.2024.1326004.
73. H. Wang et al., «A Deep Learning Model for Detecting Rhegmatogenous Retinal Detachment Using Ophthalmologic Ultrasound Images», *Ophthalmologica*, vol. 247, fasc. 1, pp. 8–18, 2024, doi: 10.1159/000535798.
74. H. Ohsugi, H. Tabuchi, H. Enno, e N. Ishitobi, «Accuracy of deep learning, a machine learning technology, using ultra-wide-field fundus ophthalmoscopy for detecting rhegmatogenous retinal detachment», *Sci Rep*, vol. 7, fasc. 1, p. 9425, ago. 2017, doi: 10.1038/s41598-017-09891-x.
75. Q. Wei, Q. Chen, C. Zhao, e R. Jiang, «Performance of automated machine learning in detecting fundus diseases based on ophthalmologic B-scan ultrasound images», *BMJ Open Ophthalmol*, vol. 9, fasc. 1, p. e001873, dic. 2024, doi: 10.1136/bmjophth-2024-001873.
76. E. Chatzimichail et al., «Transforming the future of ophthalmology: artificial intelligence and robotics' breakthrough role in surgical and medical retina advances: a mini review», *Front Med (Lausanne)*, vol. 11, p. 1434241, 2024, doi: 10.3389/fmed.2024.1434241.
77. T. H. M. Fung et al., «Artificial intelligence using deep learning to predict the anatomical outcome of rhegmatogenous retinal detachment surgery: a pilot study», *Graefes Arch Clin Exp Ophthalmol*, vol. 261, fasc. 3, pp. 715–721, mar. 2023, doi: 10.1007/s00417-022-05884-3.
78. H. Guo et al., «Prediction of Visual Outcome After Rhegmatogenous Retinal Detachment Surgery Using Artificial Intelligence Techniques», *Transl Vis Sci Technol*, vol. 13, fasc. 5, p. 17, mag. 2024, doi: 10.1167/tvst.13.5.17.

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