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Rhegmatogenous Retinal Detachment: Current Surgical Techniques

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Rhegmatogenous retinal detachment (RRD) management has evolved significantly over the recent decades. With great advancements in technique and instrumentation, all treatment modalities yield an adequate anatomical success rate; however, multimodal retinal imaging has introduced novel microstructural biomarkers that raise awareness of the importance of retinal integrity after reattachment. This issue of *Ophthalmology Rounds* explores the treatment modalities for RRD, including a historical review of the different techniques and recent advances in imaging that may help in RRD management and prognostication.

Definition

Retinal detachment (RD) is a separation of the neurosensory retina from the underlying retinal pigment epithelium (RPE), which may happen due to different pathologic mechanisms: rhegmatogenous, tractional, exudative, and combined tractional/rhegmatogenous.[1] A rhegmatogenous RD (RRD) occurs when a full-thickness defect in the neurosensory retina allows the ingress of fluid from the vitreous cavity into the subretinal space. This happens when sustained vitreoretinal traction, vitreous currents, and gravitational forces overwhelm the forces of retinal attachment, and the rate of liquified vitreous fluid influx is faster than the rate that is removed by the RPE.[2]

Epidemiology

In the United States (US), the estimated annual incidence of RRD is 10–19 per 100 000 people.[3] The Intelligent Research in Sight (IRIS) Registry found that the peak incidence of RRD occurs between 50–69 years of age, with the smallest incidence in patients aged <40 years.[4] RRD occurs predominantly in men.[5] Among other risk factors, the occurrence of a retinal break[6] and symptomatic posterior vitreous detachment (PVD) are significant contributing factors for RRD.[7,8] Retinal breaks are identified in 8%–16% of patients with acute symptomatic PVD and may progress to RRD in 30%–50% of patients if untreated.[8,9] Myopia has also been described as an important risk factor for RRD. In a 10-year retrospective cohort study of more than 80 million insured patients in the US, the incidence rate of RRD was 39-fold higher in patients with high myopia (≥5.00 D) and 3-fold higher in patients with myopia than those without myopia.[10]

Clinical Features

One of the most critical aspects of RRD examination is identification of retinal tears. The seminal paper by Lincoff and Giese helps identify the location of the causative retinal breaks by the RRD configuration **(Figure 1)**.[11] However, not all detachments obey Lincoff's rules, and 6 new rules presented by Wong et al. assist in clinically challenging RRDs **(Figure 2)**.[12] Another important aspect when examining RRDs is to check the presence and severity of complications such as proliferative vitreoretinopathy (PVR), vitreous hemorrhage, or choroidal detachment.

Time to Surgery and Prognosis

The classical cornerstone that defines the urgency of treatment in RRD is the macula status. Patients who undergo RRD repair while the fovea is attached have significantly better visual acuity (VA) outcomes when compared to fovea-involving cases, even if the central vision loss occurred in less than 24 hours.[13] Among macula-off RRDs, there has been significant controversy over the past decades on the optimum time to surgery. However, more recent studies suggest that better functional outcomes are obtained when the RRD is repaired within 3 days from symptom onset.[14]

Preoperative Imaging Features

Recent studies using baseline optical coherence tomography (OCT) in RRD have shed light on important microstructural abnormalities that were heretofore unknown or unnoticed. The first important example is outer retinal corrugations (ORCs). ORCs are a compensatory response to the hydration and lateral expansion of the outer retina and interphotoreceptor matrix in relation to the fixed inner

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Figure 1. **Lincoff rules for identification and position of a retinal break in RRD**[11]

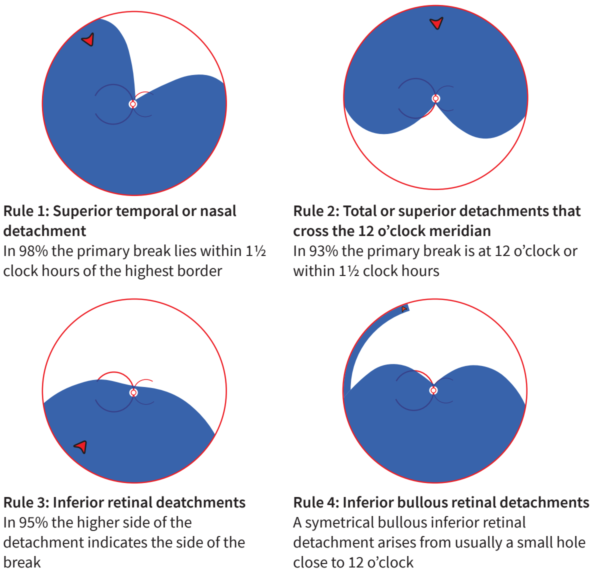

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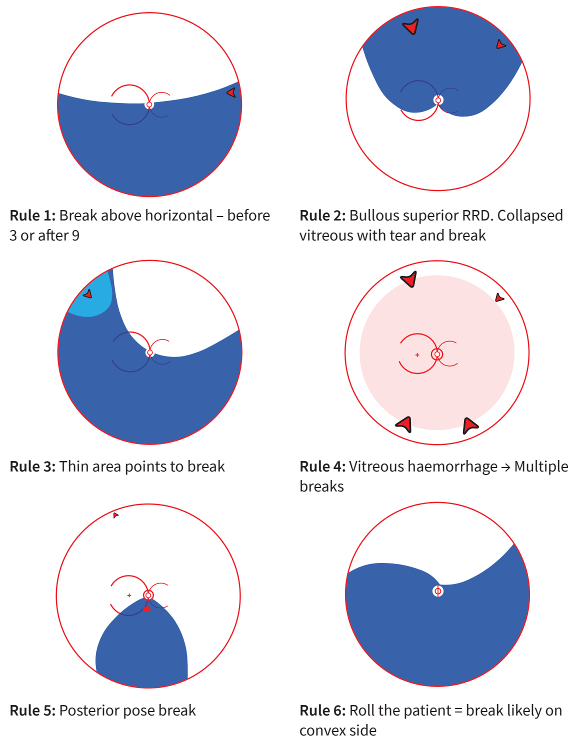
Figure 2. **Wong's rules**[12]



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retina. This generally occurs after 2 days of RRD development due to rapid and continuous influx of hypo-osmolar liquified vitreous into the subretinal space, in extensive and progressive RRDs, leading to the loss of its homeostatic regulatory control or "RPE-photoreceptor dysregulation."[15] Conversely, chronic RRDs in young, myopic eyes with an attached posterior hyaloid membrane or RRDs with atrophic holes have a relatively slower influx of liquified vitreous, which allows the RPE pump to maintain relative control of the subretinal space, resulting in a "regulated" RRD. Regulated and dysregulated RRDs have significant morphologic differences, which may impact on optimal treatment strategies.[16]

Another recent contribution made possible by OCT assessment in RRD was the identification of sequential morphologic changes that the outer retina undergoes as a detachment progresses. Our group proposed an *in vivo* grading system for dysregulated RRDs that includes 5 stages **(Figure 3)**.[17] The stages imply structural damage to the retina since they were not only associated with postoperative VA[18] but also with outer retinal band reconstitution.[19] Increasing stage was significantly associated with worse postoperative VA at 3, 6, and 12 months and was found to be an independent predictor of vision even when controlling for time to surgery, type of procedure, duration of vision loss, and baseline VA.[18] These findings highlight the need to better stratify fovea-involving RRDs since some may benefit from more urgent intervention.

Historical Management

RRD repair has evolved tremendously over the past century, beginning in 1916 when Gonin recognized that a retinal tear was the cause of RRD.[20] Using Gonin's principle, several surgeons were able to successfully treat RRDs, including Custodis, who performed the world's first scleral buckle (SB) procedure in 1949.[21] His work laid the groundwork for the current SB technique, which dominated RRD treatment paradigms until the early 2000's.[22]

In the 21st century, pars plana vitrectomy (PPV) gained significant popularity, due to its efficiency and substantial advancements in instrumentation.[23] The first description of vitreous body removal was documented in 1969 by an open-sky technique,[24] which was followed 2 years later by the creation of the first closed-system PPV set-up by Machemer.[25] From the 17-gauge instruments, PPV set-ups have progressed to 27-gauge instruments, heads-up display, 130° wide-angle viewing systems, and up to 20 000 cuts/minute.[26]

Treatment Modalities

The principal surgical techniques for RRD repair are SB, PPV, and pneumatic retinopexy (PnR), and they can be used alone or in combination. The purpose of this review is not to determine which technique is superior but to highlight their differences and demonstrate how treatment should be tailored to each specific clinical scenario.

Scleral buckle

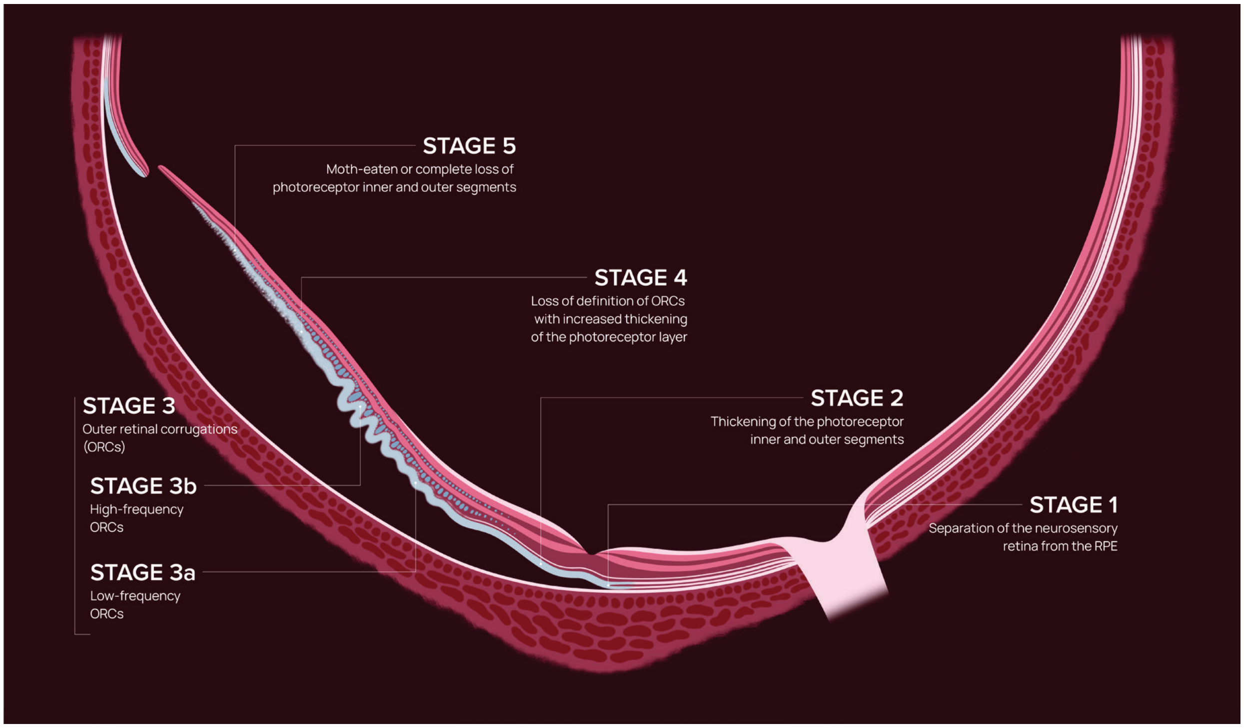
The main purpose of the SB is to alter the dynamics of intraocular currents, thereby preventing further recruitment of liquefied vitreous into the subretinal space.[27] This has been hypothesized to occur due to the physics of Bernoulli's principle.[28] Some argue that the change in the concavity of the eyeball and the resulting scleral indentation reduce traction at the retinal tear by decreasing the diameter of the vitreous base and altering the direction of the vitreous traction itself.[29]

Clinical indications

The classic indications for a primary SB are young phakic patients with an attached posterior hyaloid membrane. Other indications include myopic eyes and detachments secondary to retinal dialysis or to round atrophic holes,[29] which can yield a single-surgery success rate as high as 99%.[29,30] Absolute contraindications are severe scleral thinning/scleromalacia, advanced PVR, or a dense vitreous hemorrhage, which precludes fundus view.[29]

The Scleral Buckling versus Primary Vitrectomy in Rhegmatogenous Retinal Detachment randomized clinical trial showed that SB yields a better visual outcome than PPV for phakic patients with bullous detachments with no PVR, while

Figure 3. Stages of retinal detachment[17]



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there was no difference in anatomical success or postoperative PVR.[31] The multicentre Primary Retinal Detachment Outcomes Study showed similar results in moderately complex RRDs in phakic patients.[32] Primary SB was found to be superior to vitrectomy alone and PPV/SB in relation to single-surgery and final anatomic success rate as well as functional outcomes.

Types of exoplants

The main categories of SB deployment are radial buckle, segmental circumferential, or encircling.[29] Size, type, and location of the retinal breaks will typically determine the type, width, length, and location of the exoplant. For encircling SBs, bands and strips are the usual elements used to support the vitreous base. The band is anchored to the sclera with mattress suture or scleral tunnels and their ends are joined with a silicone Watzke sleeve. In the case of multiple retinal tears, where a high broad SB with extensive circumferential indentation is required, a grooved silicone tire is usually the element of choice.[33]

A minimized SB approach is a viable option for localized pathology.[34] In 1992, Kreissing et al. published the results of 11 years of follow-up in segmental SB showing a primary reattachment rate of 92.6%.[35] A recent study comparing segmental vs. encircling SBs showed no significant difference between these techniques in terms of single-surgery anatomical success in RRDs with comparable clinical characteristics.[36] The segmental buckle technique involves using a sponge whose size is limited to the extent of the breaks. These sponges may also be used as radial buckles to support posterior breaks and to minimize the chances of radial retinal folds.[33]

Surgical technique

Identifying all breaks with a thorough preoperative scleral depressed examination is crucial in determining the type and size of the buckling material. The classical surgery consists of a 360° peritomy followed by the isolation of recti muscles with bridle sutures. If retinopexy is performed intraoperatively, transscleral cryotherapy will be applied once all breaks have been localized.[37] A 2010 randomized trial compared intraoperative cryotherapy vs. postoperative laser photocoagulation in SB and found no significant difference in anatomical or functional success rates between the groups; however, laser retinopexy led to a faster visual recovery with fewer complications.[38]

Once the buckle type is selected, accurate suture placement or creation of scleral belt loops will determine the location of the buckle. When suturing, an important point is that the distance between the sutures will have a significant impact on the buckle height.[39] Although management of subretinal fluid in SB is controversial, the following considerations are widely accepted: drainage is rarely performed when breaks can be easily closed but almost always performed if a high and broad encircling buckle is required in a bullous detachment.[33] Nondrainage SB has been shown to be equivalent in terms of anatomical success to SBs with drainage.[40] When drainage is considered, its optimal location is usually determined by the configuration of the RRD. To avoid major choroidal vessels and have good exposure, a safe location is just above or below the lateral rectus, in a spot that will preferably be covered by exoplant.[37] The most traditional drainage involves a sclerotomy and external diathermy, followed by the 25-gauge needle transscleral technique described by Steve Charles.[41] If the eye is soft after drainage, intravitreal gas injection can help normalize the pressure. Gas injections to internally tamponade breaks are also commonly performed in association with buckling procedures, especially when multiple breaks are present.[33]

Pneumatic retinopexy

PnR is a relatively simple and minimally invasive procedure that uses a gas bubble to temporarily tamponade the retinal tear while a retinopexy (which can be performed by laser or cryotherapy) permanently closes the break. Inarguably superior in cost-effectiveness compared to SB and PPV, PnR is also associated with lower morbidity than SB and PPV, with a high single-surgery success rate.[42-44]

Clinical indications

Patient selection in PnR is crucial for its success. The classical inclusion criteria of the prospective Pneumatic Retinopexy Clinical Trial included clear media retinal detachments with no PVR, and a single break no larger than 1 clock hour located in the superior 8 hours of the retina.[45] Although patients in this study could have detachments of any extent and pseudophakia, Tornambe later showed that such factors were associated with a 10% lower success rate.[46] Conversely, phakic cases with a break <1 clock hour in the superior two-thirds of the retina with no PVR, treated with peripheral 360° retinopexy had a single-operation success close to 97%. Although the anatomic results between SB vs. PnR were not significantly different, PnR was associated with less morbidity and better postoperative VA.[45]

In 2019, the PIVOT Trial extended the ideal inclusion criteria to include any number of breaks or lattice degeneration in the attached retina, even in the inferior quadrants.[47] The single-surgery success rate of PnR was 81% vs. 93% with PPV; however, visual outcomes of patients in the PnR group were significantly superior at every time point up to 1 year of follow-up. Additionally, PnR patients had less vertical metamorphopsia and cataract formation. PnR also has better microstructural results vs. PPV with less retinal displacement, outer retinal folds, and outer retinal discontinuity.[48-51] Interestingly, the "simpler" the case, the more appropriate it can be for PnR. A *post hoc* analysis of 3 prospective clinical trials (N=231) found that the primary reattachment rate of PnR is 87% when only patients with a single break in detached retina were included and can be as high as vitrectomy (91%) when no other pathology, like lattice degeneration, is observed.[44]

Absolute contraindications to PnR include advanced PVR at the break, breaks located close to the 6 o'clock meridian, or a dense media opacity such as vitreous hemorrhage precluding fundus view.[52]

Surgical technique

Similar to SB, prior to performing PnR a thorough scleral-depressed peripheral retinal examination is essential to identify all pathologic features. Hilton's technique in the seminal Pneumatic Retinopexy Trial included transconjunctival cryotherapy with an intravitreal injection of perfluoropropane (C_3F_8; 0.3 mL) or sulphur hexafluoride (SF_6; 0.6 mL). Paracentesis is performed after 10 minutes of gas injection if the central retinal artery remains occluded.[45] Tornambe's technique included scattered laser retinopexy between the posterior insertion of the vitreous base and the ora serrata and cryopexy in the detached retinal breaks.[46] Injection of 0.5 mL of SF_6 was preceded by paracentesis, and the patient was positioned so that the bubble was opposed directly to the break. After retinal reattachment, 360° peripheral laser photocoagulation was completed.

The current technique described in the PIVOT trial includes pre-procedural laser retinopexy of all breaks and lattice degeneration in the attached retina before gas injection. An initial paracentesis is performed to withdraw ≥0.3 mL of aqueous humour. An injection of pure SF_6 follows, always 0.3 mL more than the amount removed from the tap (at least 0.6 mL).[47] Supplementary gas injection can be performed in extended criteria cases when patients have multiple breaks or if breaks are located between the 4 and 8 o'clock meridians.[53]

Patient head posturing is another important part of PnR. Most surgeons use the steamroller maneuver to expedite reattachment by using the gas bubble to push subretinal fluid through the break; however, the patient can also be positioned so that the bubble is directly opposed to the break.[46] Lee et al. found that the steamroller maneuver is associated with a faster rate of foveal reattachment compared with direct-to-the-break positioning but has a higher risk of outer retinal folds and epiretinal membrane formation.[54] Finally, once the retina reattaches, laser photocoagulation is performed in the absence of cryopexy and head positioning is continued for 7–10 days or until the bubble has reabsorbed.[47]

Pars Plana Vitrectomy

Clinical indications

Classical indications for PPV include detachments associated with significant vitreous opacities and giant (GRT) or posterior retinal tears, RRDs associated with advanced PVR, or any significant traction that cannot be overcome by an SB or laser retinopexy alone.[55] One advantage of PPV is the ability to find all retinal breaks.[56] A Cochrane review of 10 randomized clinical trials (N=1307 eyes) found no difference in primary retinal reattachment among patients who underwent SB vs. PPV alone or combined PPV/SB;[57] however, these studies excluded retinal dialysis, tractional tears, macular hole-associated detachments, and cases with significant PVR. When assessing only phakic vs. pseudophakic participants, primary reattachment did not differ in the phakic group, while the pseudophakic PPV group achieved a higher reattachment rate compared to the SB group.[57] A more recent meta-analysis concluded that no strong evidence demonstrates a benefit to adding a supplemental SB during a vitrectomy, either in phakic or pseudophakic patients.[58]

Surgical technique

The current basic set-up of a 3-port vitrectomy includes an inferotemporal trocar, which allows continuous infusion inside the vitreous chamber, a separate cutter, and an illumination probe, usually placed in the superonasal and superotemporal quadrants.[59] Several other instruments can be added, such as forceps, scissors, soft- and hard-tip cannulas, laser, and diathermy probes.

The first step of a traditional PPV is the sclerotomy.[60] Transscleral bevelled incisions are created with valved trocars that insert microcannulas through the conjunctiva into the eye. Conjunctival displacement and the creation of a 2-plane wound along with the valves improve the surgical fluidics and help decrease the risks of hypotony, wound leaks, and infection. Before opening the infusion, the intraocular placement of the infusion cannula should be confirmed. Vitreous removal occurs through the cutter probe opening and depends on the duty cycle, amount of aspiration, and cutter speed.[60] A dual-cutting system with rates of up to 20 000 cuts/minute can reduce tractional forces in the vitreous and increase flow rates.[61] High cutting rates and low vacuum allow for a safer shaving of the vitreous base in detached retinas, which is usually performed by indenting the vitreous base so that its anterior and posterior insertions can be visualized well. Endodiathermy to the tears allows their identification after the air-fluid exchange.[60]

Whenever possible, internal drainage of subretinal fluid should be made through the break; otherwise, adjunctive techniques may assist with drainage, such as perfluorocarbon liquid (PFCL). PFCL is helpful in detachments associated with GRT or PVR.[62] Although it can still be used in routine detachments, PFCL is less cost-effective and was shown to have similar outcomes vs. simpler types of drainage. [63]

Once the endolaser is performed around the causative tear, the tamponade is inserted by complete filling of the vitreous cavity. The most common tamponades used are SF6, C3F8, and either conventional or heavy silicon oil (SO). When intraocular gas is the preferred tamponade in PPV, it is diluted with air to achieve a nonexpansile isovolumetric concentration. Although tamponades have different indications, SF6 is preferred for superior, small, or single-break detachments in phakic patients due to its faster reabsorption, while C3F8 is usually reserved for larger, multiple, or inferior breaks in pseudophakic detachments.[64] A recent study found that SF6 has comparable reattachment rates to C3F8 in detachments uncomplicated by PVR or GRT.[65] The Silicone Study showed that in severe PVR, SO has superior anatomical outcomes when compared to SF6 but an equivalent effect to C3F8.[66,67] Heavy SO is usually reserved for inferior detachments and PVR cases.[62]

Post-operative Imaging Features in Retinal Detachment

Recent advances in multimodal imaging impacted the postoperative assessment of the retina. Besides being an important preoperative biomarker for RRD baseline status, ORCs also lead to outer retinal folds (ORFs), a recognized biomarker of retinal integrity following RRD repair.[68] ORFs have been associated with worse postoperative vision and were shown to occur more frequently in PPV vs. PnR.[50] Outer retinal band disruption is another relevant imaging feature of structural retinal damage, as it has been associated with reduced postoperative VA.[69,70] A *post hoc* analysis of the PIVOT trial demonstrated more frequent ellipsoid zone and external limiting membrane discontinuity in PPV vs. PnR.[51] Moreover, as previously mentioned, outer retinal disruption is also related to advanced morphologic stages of RRD at baseline.[19]

Other imaging modalities may also display important retinal biomarkers. Unintentional retinal displacement following RRD repair is evidenced by retinal vessel printings in fundus autofluorescence.[71] Displacement varies according to surgical technique, occurring more frequently in PPV vs. PnR and being associated with greater aniseikonia.[48,49] Acknowledgement and detection of retinal abnormalities may help us find ways to minimize or prevent them, with the final goal of optimizing patients' functional outcomes.

Conclusions

RRD repair continues to evolve, and modern techniques have become less invasive. However, it is important to remember that single-surgery success rate cannot be the only metric to assess successful reattachment. As treatment precision increases, greater functional and microstructural outcomes should be envisioned. The expanded identification of imaging biomarkers enabled a more detailed assessment of the postoperative retina, which continuously shows that the integrity of retinal reattachment matters and is also influenced by surgical techniques.[72]

References

1. Ghazi NG, Green WR. Pathology and pathogenesis of retinal detachment. *Eye*. 2002;16(4):411-421.
2. Mitry D, Fleck BW, Wright AF, Campbell H, Charteris DG. Pathogenesis of rhegmatogenous retinal detachment: predisposing anatomy and cell biology. *Retina Phila Pa*. 2010;30(10):1561-1572.
3. Wilkes SR, Beard CM, Kurland LT, Robertson DM, O'Fallon WM. The incidence of retinal detachment in Rochester, Minnesota, 1970-1978. *Am J Ophthalmol*. 1982;94(5):670-673.
4. Ludwig CA, Vail D, Al-Moujahed A, et al. Epidemiology of rhegmatogenous retinal detachment in commercially insured myopes in the United States. *Sci Rep*. 2023;13(1):9430.
5. Saraf SS, Lacy M, Hunt MS, et al. Demographics and seasonality of retinal detachment, retinal breaks, and posterior vitreous detachment from the Intelligent Research in Sight Registry. *Ophthalmol Sci*. 2022;2(2):100145.
6. Ferrara M, Song A, Al-Zubaidy M, et al. The effect of sex and laterality on the phenotype of primary rhegmatogenous retinal detachment. *Eye*. 2023; 37(14):2926-2933.
7. Gonin J. La pathogénie du décollement spontané de la rétine. *Ann Oculist.* 1904;132:30–55.
8. Coffee RE, Westfall AC, Davis GH, Mieler WF, Holz ER. Symptomatic posterior vitreous detachment and the incidence of delayed retinal breaks: case series and meta-analysis. *Am J Ophthalmol*. 2007;144(3):409-413.
9. Bond-Taylor M, Jakobsson G, Zetterberg M. Posterior vitreous detachment – prevalence of and risk factors for retinal tears. *Clin Ophthalmol Auckl NZ*. 2017;11:1689-1695.
10. Uhr JH, Obeid A, Wibbelsman TD, et al. Delayed retinal breaks and detachments after acute posterior vitreous detachment. *Ophthalmology*. 2020; 127(4):516-522.
11. Lincoff H, Gieser R. Finding the retinal hole. *Arch Ophthalmol*. 1971;85(5):565-569.
12. Correction: Rhegmatogenous retinal detachment: a review of current practice in diagnosis and management. *BMJ Open Ophthalmol*. 2021;6(1):e000474corr1.
13. Williamson TH, Shunmugam M, Rodrigues I, Dogramaci M, Lee E. Characteristics of rhegmatogenous retinal detachment and their relationship to visual outcome. *Eye*. 2013;27(9):1063-1069.
14. Sothivannan A, Eshtiaghi A, Dhoot AS, et al. Impact of the time to surgery on visual outcomes for rhegmatogenous retinal detachment repair: a meta-analysis. *Am J Ophthalmol*. 2022;244:19-29.
15. Muni RH, Darabad MN, Oquendo PL, et al. Outer retinal corrugations in rhegmatogenous retinal detachment: the retinal pigment epithelium–photoreceptor dysregulation theory. *Am J Ophthalmol*. 2023;245:14-24.
16. Pecaku A, Naidu SC, Demian S, Pimentel MC, Melo IM, Muni RH. Morphologic features of regulated vs. dysregulated rhegmatogenous retinal detachment using swept-source optical coherence tomography. *Am J Ophthalmol*. July 2024:S0002939424002915 [online ahead of print].
17. Martins Melo I, Bansal A, Naidu S, et al. Morphologic stages of rhegmatogenous retinal detachment assessed using swept-source OCT. *Ophthalmol Retina*. 2023;7(5):398-405.
18. Martins Melo I, Naidu S, Pecaku A, et al. Impact of baseline morphologic stage of rhegmatogenous retinal detachment on postoperative visual acuity. *Ophthalmol Retina*. 2024;8(7):624-632.
19. El-Sehemy A, Martins Melo I, Pecaku A, et al. Postoperative photoreceptor integrity and anatomical outcomes based on presenting morphologic stage of rhegmatogenous retinal detachment. *Retina*. 2024;44(5):756-763.
20. Rumpf J. Jules Gonin. Inventor of the surgical treatment for retinal detachment. *Surv Ophthalmol*. 1976;21(3):276-284.
21. Custodis E. Die Behandlung Der Netzhautabloesung Durch Umschriebene Diathermiekoagulation Und Einer Mittels Plombenaufnaehung Erzeugten Eindellung Der Sklera Im Bereich Des Risses. *Klin Monatsbl Augenheilkd.* 1956;129(4):476-495.
22. Schepens CL, Okamura ID, Brockhurst RJ. The scleral buckling procedures. I. Surgical techniques and management. *AMA Arch Ophthalmol*. 1957;58(6):797-811.

23. Moinuddin O, Abuzaitoun RO, Hwang MW, et al. Surgical repair of primary non-complex rhegmatogenous retinal detachment in the modern era of small-gauge vitrectomy. *BMJ Open Ophthalmol*. 2021;6(1):e000651.
24. Boyd B, Kasner D. Vitrectomy: a new approach to the management of vitreous [personal interview]. *Highl Ophthalmol*. 1969;11:304-309.
25. Machemer R, Buettner H, Norton EW, Parel JM. Vitrectomy: a pars plana approach. *Trans - Am Acad Ophthalmol Otolaryngol Am Acad Ophthalmol Otolaryngol*. 1971; 75(4):813-820.
26. Mohamed S, Claes C, Tsang CW. Review of small gauge vitrectomy: progress and innovations. *J Ophthalmol*. 2017;2017(1):6285869.
27. Machemer R. The importance of fluid absorption, traction, intraocular currents, and chorioretinal scars in the therapy of rhegmatogenous retinal detachments. XLI Edward Jackson memorial lecture. *Am J Ophthalmol*. 1984;98(6):681-693.
28. Wong D, Chan YK, Bek T, Wilson I, Stefánsson E. Intraocular currents, Bernoulli's principle and non-drainage scleral buckling for rhegmatogenous retinal detachment. *Eye*. 2018;32(2):213-221.
29. Wang A, Snead MP. Scleral buckling—a brief historical overview and current indications. *Graefes Arch Clin Exp Ophthalmol*. 2020;258(3):467-478.
30. Ung T, Comer MB, Ang AJS, et al. Clinical features and surgical management of retinal detachment secondary to round retinal holes. *Eye Lond Engl*. 2005;19(6):665-669.
31. Heimann H, Bartz-Schmidt KU, Bornfeld N, et al. Scleral buckling versus primary vitrectomy in rhegmatogenous retinal detachment: a prospective randomized multicenter clinical study. *Ophthalmology*. 2007;114(12):2142-2154.
32. Ryan EH, Ryan CM, Forbes NJ, et al. Primary Retinal Detachment Outcomes Study Report Number 2: phakic retinal detachment outcomes. *Ophthalmology*. 2020;127(8):1077-1085.
33. Wilkinson CP, Bhavsar AR. Scleral buckling surgery. In: Bhavsar AR (ed.). *Retina and Vitreous Surgery*. Amsterdam (Netherlands); Elsevier B.V.; 2008. Pages 1-14.
34. Kreissig I. View 1: Minimal segmental buckling without drainage. *Br J Ophthalmol*. 2003;87(6):782-784.
35. Kreissig I, Rose D, Jost B. Minimized surgery for retinal detachments with segmental buckling and nondrainage. An 11-year follow-up. *Retina Phila Pa*. 1992;12(3):224-231.
36. Hwang C, Astafurov K, Roth D. The use of encircling versus segmental buckling as primary surgery for retinal detachment repair. *Invest Ophthalmol Vis Sci*. 2021;62(8):3102.
37. Williams GA, Aaberg Jr TA. Techniques of scleral buckling. In: Ryan SJ, Wilkinson CP (eds.). *Retina. Volume 3, 4th Edition*. Philadelphia (PA); Elsevier Mosby; 2006. Pages 2035-2207.
38. Lira RPC. Cryotherapy vs laser photocoagulation in scleral buckle surgery: a randomized clinical trial. *Arch Ophthalmol*. 2010;128(12):1519.
39. Ramasamy K, Naresh Babu K, Kohli P, Dhipak Arthur B. Scleral buckling and management of retinal dialysis. In: Jain A, Natarajan S, Saxena S (eds.). *Cutting-Edge Vitreoretinal Surgery*. Singapore; Springer; 2021. Pages 115-132.
40. Hilton GF. The drainage of subretinal fluid: a randomized controlled clinical trial. *Trans Am Ophthalmol Soc*. 1981;79:517-540.
41. Charles ST. Controlled drainage of subretinal and choroidal fluid. *Retina*. 1985;5(4): 233-234.
42. Elhusseiny AM, Yannuzzi NA, Smiddy WE. Cost analysis of pneumatic retinopexy versus pars plana vitrectomy for rhegmatogenous retinal detachment. *Ophthalmol Retina*. 2019;3(11):956-961.
43. Goldman DR, Shah CP, Heier JS. Expanded criteria for pneumatic retinopexy and potential cost savings. *Ophthalmology*. 2014;121(1):318-326.
44. Pecaku A, Shor R, Martins Melo I, Hillier R, Muni RH. Assessment of the success rate of pneumatic retinopexy in patients with rhegmatogenous retinal detachment and one break only. *Invest Ophthalmol Vis Sci*. 2023;64(8):5292.
45. Tornambe PE, Hilton GF. Pneumatic retinopexy: a multicenter randomized controlled clinical trial comparing pneumatic retinopexy with scleral buckling. The Retinal Detachment Study Group. *Ophthalmology*. 1989;96(6):772-784.
46. Tornambe PE. Pneumatic retinopexy: the evolution of case selection and surgical technique. A twelve-year study of 302 eyes. *Trans Am Ophthalmol Soc*. 1997;95:551-578.
47. Hillier RJ, Felfeli T, Berger AR, et al. The Pneumatic Retinopexy versus Vitrectomy for the Management of Primary Rhegmatogenous Retinal Detachment Outcomes Randomized Trial (PIVOT). *Ophthalmology*. 2019;126(4):531-539.
48. Brosh K, Francisconi CLM, Qian J, et al. Retinal displacement following pneumatic retinopexy vs pars plana vitrectomy for rhegmatogenous retinal detachment. *JAMA Ophthalmol*. 2020;138(6):652.
49. Francisconi CLM, Marafon SB, Figueiredo NA, et al. Retinal displacement after pneumatic retinopexy versus vitrectomy for rhegmatogenous retinal detachment (ALIGN). *Ophthalmology*. 2022;129(4):458-461.
50. Lee WW, Bansal A, Sadda SR, et al. Outer retinal folds after pars plana vitrectomy vs. pneumatic retinopexy for retinal detachment repair. *Ophthalmol Retina*. 2022;6(3):234-242.
51. Muni RH, Felfeli T, Sadda SR, et al. Postoperative photoreceptor integrity following pneumatic retinopexy vs pars plana vitrectomy for retinal detachment repair: a post hoc optical coherence tomography analysis from the Pneumatic Retinopexy Versus Vitrectomy for the Management of Primary Rhegmatogenous Retinal Detachment Outcomes Randomized Trial. *JAMA Ophthalmol*. 2021;139(6):620.
52. Stewart S, Chan W. Pneumatic retinopexy: patient selection and specific factors. *Clin Ophthalmol*. 2018;12:493-502.
53. Alali A, Bourgault S, Hillier RJ, Muni RH, Kertes PJ. Sequential pneumatic retinopexies for the treatment of primary inferior rhegmatogenous retinal detachments with inferior breaks: The Double-Bubble Approach. *Retina*. 2020;40(2):299-302.
54. Lee WW, Bansal A, Hamli H, Oquendo P, Kertes P, Muni RH. Anatomic and functional outcomes with the steamroller maneuver versus direct to break positioning following pneumatic retinopexy for rhegmatogenous retinal detachment repair. 42nd ASRS Annual Scientific Meeting, Stockholm, Sweden, 2024.
55. Sultan ZN, Agorogiannis EI, Iannetta D, Steel D, Sandinha T. Rhegmatogenous retinal detachment: a review of current practice in diagnosis and management. *BMJ Open Ophthalmol*. 2020;5(1):e000474.
56. Brazitikos PD, Androudi S, Christen WG, Stangos NTr. Primary pars plana vitrectomy versus scleral buckle surgery for the treatment of pseudophakic retinal detachment: a randomized clinical trial. *Retina*. 2005;25(8):957-964.
57. Znaor L, Medic A, Marin J, Binder S, Lukic I, George J. Pars plana vitrectomy versus scleral buckle for repairing simple rhegmatogenous retinal detachments. *Cochrane Database Syst Rev*. 2019 Mar 8;3(3):CD009562..
58. Rosenberg DM, Ghayur HS, Deonarain DM, et al. Supplemental scleral buckle for the management of rhegmatogenous retinal detachment by pars plana vitrectomy: a meta-analysis of randomized controlled trials. *Ophthalmologica*. 2022;245(2):101-110.
59. Caporossi T, Scampoli A, Tatti F, et al. Two-port "dry vitrectomy" as a new surgical technique for rhegmatogenous retinal detachment: focus on macula-on results. *Diagnostics*. 2023;13(7):1301.
60. Arevalo JF, Berrocal MH, Arias JD, Banaee T. Minimally invasive vitreoretinal surgery: is sutureless vitrectomy the future of vitreoretinal surgery? *J Ophthalmic Vis Res*. 2011;6(2):136-144.
61. Steel DH, Charles M, Zhu Y, Tambat S, Irannejad AM, Charles S. Fluidic performance of a dual-action vitrectomy probe compared with a single-action probe. *Retina Phila Pa*. 2022;42(11):2150-2158.
62. Hussain, Banerjee. Densiron 68 as an intraocular tamponade for complex inferior retinal detachments. *Clin Ophthalmol*. 2011;5:603-607.
63. Vo LV, Ryan EH, Ryan CM, et al. Posterior retinotomy vs perfluorocarbon liquid to aid drainage of subretinal fluid during primary rhegmatogenous retinal detachment repair (PRO Study Report No. 10). *J Vitreoretin Dis*. 2020;4(6):494-498.
64. Schwartz S, Vaziri K, Kishor K, Flynn H. Tamponade in the surgical management of retinal detachment. *Clin Ophthalmol*. 2016;10:471-476.
65. Schöneberger V, Li JQ, Menghesha L, Holz FG, Schaub F, Krohne TU. Outcomes of short- versus long-acting gas tamponades in vitrectomy for rhegmatogenous retinal detachment. *Int J Retina Vitr*. 2024;10(1):16.
66. Vitrectomy with silicone oil or sulfur hexafluoride gas in eyes with severe proliferative vitreoretinopathy: results of a randomized clinical trial. Silicone Study Report 1. *Arch Ophthalmol*. 1992;110(6):770.
67. Vitrectomy with silicone oil or perfluoropropane gas in eyes with severe proliferative vitreoretinopathy: results of a randomized clinical trial: Silicone Study Report 2. *Arch Ophthalmol*. 1992;110(6):780.
68. dell'Omo R, Tan HS, Schlingemann RO, et al. Evolution of outer retinal folds occurring after vitrectomy for retinal detachment repair. *Investig Opthalmology Vis Sci*. 2012;53(13):7928.
69. Wakabayashi T, Oshima Y, Fujimoto H, et al. Foveal microstructure and visual acuity after retinal detachment repair: imaging analysis by Fourier-domain optical coherence tomography. *Ophthalmology*. 2009;116(3):519-528.
70. Gharbiya M, Grandinetti F, Scavella V, et al. Correlation between spectral-domain optical coherence tomography findings and visual outcome after primary rhegmatogenous retinal detachment repair. *Retina Phila Pa*. 2012;32(1):43-53.
71. Shiragami C, Shiraga F, Yamaji H, et al. Unintentional displacement of the retina after standard vitrectomy for rhegmatogenous retinal detachment. *Ophthalmology*. 2010;117(1):86-92.e1.
72. Muni RH, Lee WW, Bansal A, Ramachandran A, Hillier RJ. A paradigm shift in retinal detachment repair: The concept of integrity. *Prog Retin Eye Res*. 2022;91:101079.

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