Review

Rhegmatogenous retinal detachment treatment guidelines

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A B S T R A C T

This paper outlines general guidelines following the initial diagnosis of rhegmatogenous retinal detachment. These include preoperative evaluation, treatment, possible intra- and post-operative complications, retinal re-detachment, and all therapeutic options available for each case. Treatment of the traumatic retinal detachment is also described, due to its importance and peculiarities. Treatment or prophylactic guidelines are suggested for the different types of retinal detachment described. These are based on both the experience of the ophthalmologists that have participated in preparing the guidelines, and also on evidence-based grading linked to bibliographical sources. However, these guidelines should not be interpreted as being mandatory. Given that there is a wide spectrum of options for the treatment of retinal detachment, the surgeons’ experience with one or other surgical technique will be of utmost importance in obtaining the best surgical result. As guidelines, they are intended as an additional aid to the surgeon during the decision-making process, with the expectation that the final choice will still be left to the surgeon’s judgment and past experience.

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Palabras clave:
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Degeneraciones retinianas periféricas
Fotocoagulación láser
Vitrectomía transconjuntival

Guías de tratamiento del desprendimiento de retina rhegmatogénos

Resumen

El objetivo de esta guía es describir unas directrices generales del proceso seguido por el cirujano oftalmólogo desde el diagnóstico del desprendimiento de retina, pasando por su evaluación preoperatoria, hasta su tratamiento, complicaciones intra y postoperatorias, fracaso o recidiva del desprendimiento de retina rhegmatogénos, y las posibles alternativas terapéuticas en cada caso. También describiremos el tratamiento del desprendimiento de retina traumático por su importancia y peculiaridades.

Se sugieren líneas de tratamiento o profilaxis para las diferentes situaciones del desprendimiento de retina en base a las variables encontradas, a la experiencia de los cirujanos oftalmólogos de la comisión que ha redactado, y a la revisión bibliográfica con los distintos niveles de evidencia, pero no pretende establecer criterios de obligado cumplimiento, sobre todo considerando que el desprendimiento de retina tiene amplias posibilidades de tratamiento, y que la experiencia del cirujano en una u otra técnica va a ser fundamental en la obtención del mejor resultado quirúrgico. Como guías que son, solamente pretenden asesorar al cirujano en la práctica diaria, dejando en sus manos y en su experiencia la mejor opción terapéutica.

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Guideline objectives

This paper outlines general guidelines of the process followed by ophthalmological surgeons after the initial diagnosis of rhegmatogenous retinal detachment. These include preoperative evaluation, treatment, intra- and post-operative complications, failure or relapse of the rhegmatogenous retinal detachment (RRD), and all therapeutic options available for each case. Treatment of traumatic retinal detachment is also described.

Treatment or prophylaxis lines are suggested for the various situations in retina detachment on the basis of identified variables, the experience of the ophthalmological surgeons of the commission that has drawn up said variables and the bibliographical review with various levels of evidence. However, it does not aim at establishing mandatory criteria, above all considering that retina detachment involves a range of treatment possibilities and that the surgeon’s experience in each technique will be crucial for obtaining the best surgical result. Following the spirit of guidelines, this paper only aims at providing advice for surgeons in their daily practice, leaving the choice of the best therapeutic option to their own criteria and experience. The fact that some of said options are not comprised within this paper as recommended treatments cannot be considered at all as poor professional practice or an infringement of lex artis ad hoc.

The guidelines have been established on the basis of a broad review of literature and existing protocols by a committee appointed by the Spanish Retina and Vitreous Society, which has discussed the various therapeutic options available at present and their most accepted indication. Accordingly, the clinical, diagnostic and therapeutic recommendations are grounded on scientific knowledge and levels of evidence. To this end, a bibliographic search was carried out in PubMed and Cochrane Library Plus, for the terms “rhegmatogenous retinal detachment” and selecting referenced articles in English and Spanish.

Evidence levels and recommendation grades are based on the US Agency for Health Research and Quality:

- Evidence level 1. 1a: the evidence is obtained from the meta-analysis of controlled, randomized and when designed trials. 1b: the evidence is obtained from at least one randomized controlled trial.
- Evidence level 2. 2a: the evidence is obtained from at least one well-designed non-randomized controlled trial. 2b: the evidence is obtained from at least one not completely experimental, well-designed designed trial such as a cohort study. This refers to a situation in which the application of an intervention is beyond the control of researchers but its effect can be evaluated.
- Evidence level 3. The evidence is obtained from descriptive well-designed non-experimental studies such as comparative, correlation or case and control studies.
- Evidence level 4. The evidence is obtained from documents or statements by expert committees or clinical experiences of well reputed authorities or case series studies.

In order to enhanced the usability of these guidelines, the levels of scientific evidence and clinical recommendations are included, excepting in the primary RRD and re-detachment where they are included at the end to enable a more detailed analysis and provide a broader vision.
Predisposing injuries and prophylaxis of rhegmatogenous retinal detachment

RRD prevention continues to be a fundamental part of daily ophthalmological practice. Various prophylaxis methods have been proposed but there is no study that adequately determines the value of each method.

Clinical relevance
- 7% of the population over 14 exhibits asymptomatic retinal tears.
- Lattice degenerations appear in 8% of the general population and their existence is related to 30% of RRD.
- Non-traumatic RRD has an incidence of 1/10,000 persons/year, and the prevalence of pseudophakic RRD increases up to 1–3%.

Clinical precursors
RRD precursors are posterior vitreous detachment (PVD), the presence of symptomatic and asymptomatic retinal tears, lattice degeneration and retinal tufts.

- PVD: 15% of patients with symptomatic PVD (myodesopsia, photopsia or blurred vision due to vitreous hemorrhage) exhibit retina tear in funduscopic evaluations. There is a correlation between the degree of vitreous hemorrhage and the probability of exhibiting retinal tear. The presence of pigmented cells, vitreous or retinal hemorrhage and the appearance of new symptoms are correlated to the presence of retinal tear.
- Symptomatic retinal tears: these are caused by vitreoretinal traction with acute PDD or tear associated to photopsia and myodesopsia.
- Lattice degeneration: it causes RRD through 2 mechanisms, i.e., holes without vitreoretinal traction or horseshoe tears associated to PVD.

Risk factors for developing rhegmatogenous retina detachment

The main factors are myopia, lattice degeneration, cataract surgery, trauma, RRD history in the contralateral eye and the Stickler syndrome. Corneal or phakic lens refractive surgery does not constitute a risk factor. The presence of vitreoretinal pathology per se does not justify prophylactic treatment because some conditions must be fulfilled.

- Myopia: over 50% of primary detachments of color in myopic patients. Patients with 1–3D myopia have 4 times greater risk than non-myopic population, while goals with myopia exceeding 3D have 10 times more risk.
- Lattice degeneration: it appears in 20–30% of patients with primary RRD.
- Cataract surgery: the risk of post-surgery RRD is of 1% and is higher with the removal of transparent lens in myopic patients and in posterior capsule tears.
- There is no consensus on the role of YAG capsulotomy in the incidence of RRD.
- RRD in the contralateral eye: the risk of detachment in the contralateral eye increases 10%.  

Clinical situations

Symptomatic eyes
Eyes with symptoms include myodesopsia and/or photopsia associated to acute PVD. Approximately 15% of eyes with symptomatic PVD develop retinal tears.

The main risk factor is vitreous hemorrhage with the association of the above-mentioned risk factors.

- Horseshoe tears: it is recommended to establish preferably prophylactic treatment (evidence level 1/recommendation A).
- Trophic holes: evolution to detachment is rare. Treatment is recommended if associated to vitreoretinal paravascular traction.

Asymptomatic eyes without high risk factors
In phakic, non-myopic eyes without familial or contralateral eye history, the risk of developing RRD is low despite the presence of vitreoretinal pathology.

- Lattice degeneration: in phakic eyes without familial or contralateral eye retina detachment history prophylactic treatment is recommended only in the presence of symptoms (evidence level 2/recommendation grade B). In myopic patients it is recommended to carry out regular observation and treatment when symptoms arise.
- Retinal tufts: in eyes without risk factors prophylactic treatment is not recommended.
- Asymptomatic tears: in eyes without contralateral RRD prophylactic treatment is not recommended (evidence level 2/recommendation grade B).

Asymptomatic eyes with high risk factors
Myopia, previous cataract surgery and family history are the main risk factors in eyes without RRD antecedents in the contralateral eye.

Myopia. Lattice degeneration: the presence of lattice degeneration with trophic holes is not correlated to the degree of myopia. No benefits have been demonstrated from prophylactic treatment in myopic patients exceeding 6 D (evidence level 2/recommendation grade B). Retinal tufts: prophylactic treatment is not recommended. Asymptomatic tears: more frequent in myopic patients. If pigmented and with signs of chronicity, prophylactic treatment is not recommended.

Pseudophakic and aphakic eyes. Lattice degeneration and retinal tufts: natural evolution is poorly documented. There are no studies describing the value of prophylactic treatment. Asymptomatic tears: in horseshoe tears, prophylactic treatment is recommended despite the lack of information due to persistent traction at the edge.
Familial retina detachment history. Prophylactic treatment for lattice degeneration and tufts is recommended in these cases, above all if the contralateral eye has been involved. Clinical studies describing the usefulness of prophylactic treatment were not found.\textsuperscript{1,20}

Patients with rhegmatogenous retinal detachment in the contralateral eye
Vitreoretinal pathological changes generally occur bilaterally, increasing the risk of RRD in the contralateral eye (from 9 to 40%).\textsuperscript{21,22}

Asymptomatic phakic contralateral eye. Lattice degeneration: moderate benefits from prophylactic treatment. Recommended in patients with poor surgical results in the contralateral eye or who cannot comply with clinic follow-up\textsuperscript{21,22} (evidence level 2/recommendation grade B). Retinal tufts: only bilaterally in 6% of cases. Prophylactic treatment is not recommended.\textsuperscript{15,16} Asymptomatic tears: prophylactic treatment is recommended\textsuperscript{13,14} (evidence level 3/recommendation grade C). Giant tear: clinical information is lacking. In the presence of high myopia, degenerative changes of the vitreous gel and presence of white with pressure, regular checkups are advised.\textsuperscript{23,24}

Asymptomatic pseudophakic contralateral eye. Previous RRD history and risk associated to cataract surgery in the contralateral eye have made prophylactic treatment recommendable in these cases. Lattice degeneration: prophylactic treatment is recommended despite the lack of information, only in cases without PVD. In addition, it is necessary to regularly evaluate peripheral areas having normal appearance. If PVD exists, prophylactic treatment is not equally effective.\textsuperscript{20,21,25} Retinal tears: prophylactic treatment is recommended above all in horseshoe tears\textsuperscript{1} (evidence level 3/recommendation grade C). Giant tears: prophylactic treatment is recommended, above all with vitreous gel liquefaction\textsuperscript{23,24} (evidence level 2/recommendation grade B).

Prophylactic treatment
At this time, the most widely applied treatment is laser photocoagulation. 2/3 rows of confluent impacts must be made around each degeneration or tear. The most important aspect of treatment is to complete the photocoagulation of the tear or degeneration anterior edge up to the ora. The scleral depression enables adequate visualization and exposure of the anterior margin of the tear or degeneration. Alternatively, trans-scleral or trans-conjunctival cryotherapy can be utilized although it induces more inflammation.

Horseshoe tears are the type of tears most frequently treated. Failure of prophylactic treatment is due to the accumulation of subretinal fluid, maybe in the anterior edge of the tear, and the persistence of traction. Adhesion created by means of laser develops faster than with cryotherapy\textsuperscript{1} although it is less solid (Table 1).

| Table 1 – Therapeutic options. |
|-----------------------------|-----------------------------|
| Type of lesion              | Treatment                   |
| Acute symptomatic horseshoe-shaped tear | Treatment preferred |
| Acute symptomatic trophic hole | Treatment may not be necessary |
| Traumatic retinal tears     | Treatment recommended       |
| Asymptomatic horseshoe tear | Follow-up without treatment. |
| Asymptomatic trophic hole   | If traction appears, treatment must be considered |
| Asymptomatic lattice degeneration without trophic holes | Rarely treated |
| Asymptomatic lattice degeneration with trophic holes | Treated only if PVD originates horseshoe tear |

Presurgery evaluation of rhegmatogenous retina detachment

Symptomatology
- Photopsia and myodesopsia (on previous days).
- Relative scotoma in the visual field corresponding to the detached retina area. For instance, with a superior temporal detachment, the patient will refer inferior nasal scotoma. If the retinal involvement is very peripheral, it could be asymptomatic (subclinic).
- Metamorphopsia, micropsia and central vision loss (if the macula is involved).

Clinic and diagnostic
Ocular fundus findings:
- The detached retina presents a wavelike and mobile appearance mainly in recent RRD, extending from the ora serrata to the optic nerve. Generally, vitreous syneresis is observed, PVD and traction are usually present in the retinal tears (Fig. 1).
- On rare occasions, RRD can be found without PVD. These are more prevalent in high myopia patients and are secondary to trophic holes.

In longer evolution detachments, the retina may be thinned and exhibit fixed folds secondary to PVR and retinal cysts (Fig. 2).
In the presurgery evaluation it is necessary to describe the extension of the RRD and locate all the retinal tears with indirect ophthalmoscopy and scleral depression. The Lincoff rules\textsuperscript{26} make it possible to locate the primary tear in 90–97% of cases (in pseudophakic patients, this percentage would be lower and the rules may not be fulfilled):
- Rule 1: upper temporal or nasal RRD: in 98% of cases the primary tear is at less than half past one o’clock angle from the upper edge.
- Rule 2: total or upper RRD crossing the 12 o’clock Meridian: in 93% of cases the tear is at 12 o’clock or in a triangle the
Fig. 1 – Retina detachment with 7 days evolution. A bullous detachment with two paravascular equatorial tears. Traces of hemorrhage and evidence of vitreous traction in the posterior edge of the tears can be observed.

vertex of which is at the ora serrata and on the sides of which half past one o’clock angles extend from both sides of the 12 o’clock meridian.

- Rule 3: lower detachments: in 95% of cases the upper side of the RRD indicates the side of the disk having the upper tear.
- Rule 4: lower bullous RRD: the origin of this type of RRD is an upper tear.
- In 3–21% of RRD, according to different series, the tears cannot be located prior to surgery27 (Fig. 3).

Supplementary tests

- Presurgery visual acuity: this is the main factor that determines post-surgery visual acuity28–33. The exploration thereof would be extremely important for the prognosis when diagnosing RRD. Resolving macular detachment between the first and seventh day of its occurrence does not modify or influence final visual acuity.34 Visual recovery after RRD is fast during the first 3 months but it continues

Fig. 2 – Total retina detachment with one month evolution and posterior vitreoretinal proliferation grade C4. The retina can be observed to be thinned, with fixed retinal folds and variation in the usual direction of retinal vessels. The Linoff rules (described in the text and in Fig. 3) are not fulfilled in this type of detachment.

Fig. 3 – Rhegmatogenous retina detachment.
to increase 5 years after surgery\textsuperscript{30} (evidence level 3/recommendation grade C).
- Broad field retinography: useful for recording the anatomy of RRD, establishing the presence of vitreoretinal proliferation (VRP) and macular involvement as these could influence the visual evolution of RRD after surgery. Optomap\textsuperscript{3} broad field retinographs are particularly useful for this pathology.
- Optic coherence tomography (OCT): OCT has been utilized in the presurgery period to determine the height of the RRD and evidence the presence of cystic macular edema (CME) or macular hole (MH).\textsuperscript{35} These 3 factors will influence the visual recovery degree in the post-surgery period.\textsuperscript{30} It is also very useful to detect flat detachments in the posterior pole of myopia Magnus patients. The main limitation of this technique is full of visualization of the macula in bullous RRD (evidence level 3/recommendation grade C).

Differential diagnostic

This diagnostic must be established with other types of retinal detachment, comprising:
- Exudative detachments: typically, it does not reach the ora serrata or exhibit retinal tears, and the fluid changes position due to its high molecular weight when the position of the head changes. It can be associated to choroidal tumors, more frequently to choroidal hemangioma and occasionally to choroidal melanoma or choroidal metastasis.
- Tractional detachment: the retina is not mobile and exhibits a concave shape with stretching proliferation strips. This detachment is called by vasoproliferative pathology, the most frequent of which is diabetic retinopathy.
- Retinoschisis: a dome-shaped peripheral cystoid degeneration with cysts in the external and plexiform layer, bilateral and generally symmetrical in 50–80% of cases. This degeneration is mostly found in the inferior temporal area. Retinoschisis causes absolute scotoma and does not present tobacco dust cells in the vitreous.

Chronic RRD can sometimes be confused with retinoschisis. It is typical to observe marking lines, alterations in the underlying retina pigment epithelium (RPE) and microcysts in chronic RRD. On other occasions, chronic RRD patients exhibit or suffer a retinoschisis process.

Treatment of primary retinal detachment

The principles of RRD surgery were established by Jules Gonin\textsuperscript{36} and remain valid today. The essential steps of this surgery are adequate identification, localization and treatment of all tears.

The selection of surgical technique for primary RRD surgery is the most important predictive factor of the primary and final anatomic success rate as well as functional success.\textsuperscript{37} In order to objectively illustrate the evidence found in literature on the main techniques utilized in this surgery, we have defined:

- **Primary anatomic success**: complete retinal reapplication after the first surgery.
- **Final anatomic success**: complete retinal reapplication after one or more surgeries.
- **Functional success**: if the presurgery MSVC is maintained or improved or if a final BCVA of \( \geq 20/200 \) is obtained.

In addition, primary RRD is classified as phakic and pseudophakic and as non-complex and complex depending on the presence of minor VRP signs of grade B or greater.\textsuperscript{38}

However, it is important to bear in mind the existence of limitations in the comparison of published studies, including surgical technique variations and inclusion/exclusion criteria as well as in the definition of primary and secondary variables. For instance, some studies performed photocoagulation over the tear and others which performed 360° photocoagulation in a series of cases, and both were included within the pars plana vitrectomy group (PPV).

The choice of surgical technique will be based on the characteristics of the rhegmatogenous detachment and the peculiarities of each patient as well as on the experience of the surgeon in each surgical technique.

At this time, the 2 most frequent surgical techniques are scleral surgery and PPV, pneumatic retinopexy being reserved for selected cases. Other options such as laser marking or observation are indicated in exceptional circumstances.\textsuperscript{39}

**Scleral surgery**

Scleral surgery is considered to be the reference technique for phakic primary retinal detachment. It is the most consolidated surgical technique and the one with published results having the longest follow-up periods.\textsuperscript{40}

The anatomic and functional results of the main series have become the reference in comparison with other surgical techniques. These results have remained stable for over 2 decades. In recent years, vitrectomy techniques have not demonstrated primary anatomic results superior to those of scleral surgery.

Scleral surgery indications are not considered for primary cases with tears posteriorly to the equator, giant tears, media opacity cases which hinder adequate ocular fundus exploration and cases with complex retina detachment. In addition, special attention must be given to patients operated for glaucoma.

In a review of 7 articles comprising 4940 eyes the published primary reapplication rate was of 75–91%. The final reapplication rates with multiple interventions were of 88–97%. Of these patients, 39–56% obtained a final visual acuity of 20/50 or higher.\textsuperscript{41} The study with the longest follow-up time (20 years) has demonstrated a primary reapplication rate of 82% and a final rate of 95%.\textsuperscript{40}

The most recent multicenter, prospective and randomized studies comparing scleral surgery versus PPV in the patients with non-complex primary detachment revealed a primary reapplication rate of 63.6% in patients treated with scleral surgery and of 63.8% in those treated with the vitrectomy (no significant differences).\textsuperscript{41}

The primary reapplication rates in pseudophakic retinal detachment treated with scleral surgery is generally lower than the rate for phakic cases. One of the main consecutive series comprising 266 pseudophakic or aphakic cases
demonstrated a primary reapplication rate of 77%, with the
final reapplication rate being of 95%.29
Sub-retinal fluid in bullous detachments can be drained by
means of trans-scleral drainage. One option would be to
not drain, injecting a stopping agent in the vitreous cavity (pure
air or gas) and await the reabsorption of the subretinal fluid
due to the action of the RPE pump.

Pars plana vitrectomy techniques
This technique has gained popularity over scleral surgery
in recent years, mainly for primary pseudophakic retinal
detachment.42 Intra-surgery visualization and identification
of retinal tears is superior to presurgery visualization and
identification with current PPP systems. Probably this is one of
the main reasons for the tendency to use this technique as first
choice for treating primary pseudophakic RRD. In a prospec-
tive and retrospective case series, primary reapplication rates
are of 75–100% with a final rate of 96–100%.42
In recent years various studies have been published which
demonstrate the superiority of PPV techniques over classic
scleral surgery in the treatment of noncomplex pseudophak-
ic primary RRD. This evidence is sustained in meta-analysis
and 2 comparative and randomized prospective clinical
studies.37,43,44
The first comparative, prospective and randomized clini-
cal study37 that compared scleral surgery and PPV without
flat episcleral procedure revealed a higher primary reap-
llication rates in patients treated with PPV (94%) compared
to patients treated with scleral surgery (83%). The second pub-
lished clinical study44 comprised a higher number of cases
and in the subgroup of pseudophakic patients, reapplication
rates with scleral surgery were lower (53.4%) than those
obtained with vitrectomy (72%). In this study, the decision
to associate scleral implant to vitrectomy was up to the surgeon
and therefore was not randomized.
The meta-analyses carried out on surgical treatments for
RRD concluded that vitrectomy techniques with or without
circumferential procedure are superior to conventional scleral
surgery.37

Microincision techniques
In the past 3 years primary retinal detachment clinical case
series have been published on patients treated with vitrec-
tomy without scleral procedure with gauge 23 and 25 G.45-48
A majority of authors have included non-complex primary
detachment. Primary reapplication rates are within the range
of those published with 20 G vitrectomy.
Experiences with 23 G are very satisfactory due to the pre-
cision of the work with small gauge vitrectomes over the base
of the vitreous, above all when control over the working cycle
of the vitrectome is available, as this enables high cutting fre-
quency and enhances traction control over the retina and the
base of the vitreous, thus diminishing the risk of tears.
Small incision surgery is not the equivalent of suture-
or peritomy-free surgery as it can be associated to scleral
surgery and requires sutures at the end of the intervention.
The smaller size of sclerotomies and enhanced control over
fluids avoids losses through microcannules and enables an
improved surgical approach for possible re-interventions. The
utilization of gas as a buffer at the end of the surgery dimin-
ishes the risk of loss through sutureless sclerotomies.

Aspects to be considered in vitrectomy techniques
for pseudophakic rhegmatogenous retina detachment

Association of circumferential procedure
In the Scleral Buckling versus Primary Vitrectomy in Rheg-
matogenous Retinal Detachment (SPR Study), a multicenter,
prospective and randomized study by Heimann et al., 41 the
decision of adding circumferential procedure to vitrectomy
is left to the surgeon. The group in which the circum-
ferential procedure was added exhibited re-detachment in
11.4% of cases versus 40.9% in which the procedure was not
added. On the basis of this study it is recommended to asso-
ciate equatorial indentation to vitrectomy in pseudophakic
patients. However, other non-randomized and retrospective
studies that also compared vitrectomy with and without scler-
sal surgery in non-complicated primary RRD did not observe
differences when adding scleral procedure.49,50
This controversy in the literature means that the need to
add a circumferential procedure to vitrectomy is not clear even
though the study with the highest available scientific evidence
recommends it.

Types of tamponade agents
The function of the buffer agents in the post-surgery period is
to enable the reabsorption of the sub-retinal fluid at the edge of
each tear in order to achieve adhesion of the retinal edge with
the retina pigment epithelium. The most widely used buffer
agents is gas, either in the form of air, SF6 or C3F8. The choice
of gas or the concentration thereof will depend on the location
and size of the tears, the duration of the retina detachment
and the presence of VRP. In flat detachments with an extended
dissection of the cortical gel around the tears or superior tears,
air or SF6 can be applied at a nonexpandable concentration
(18%). In contrast, when the dissection or drainage of the sub-
retinal fluid are incomplete or in the presence of multiple tears
(some with lower predominance or presence of VRP) a longer
duration agent must be applied such as C3F8 at a nonexpand-
able concentration (14%) or silicone oil (SO). In addition, C3F8
can be applied at a concentration lower than 8–10% to achieve
an intermediate buffering period.

Inferior tears are more difficult to stop with intraocular gas
and require a nearly complete filling of the vitreous cavity. If an
equatorial circumferential indentation is placed, it improves
the contact area and the buffer effect.
When the sub-retinal fluid is drained completely from the
edges of the retinal tear, in small tears the use of a buffer agent
during the post-surgery period can be avoided.50
SO has been used in the treatment of complex RRD
cases associated to VRP, giant tears, penetrating traumatism,
detachment associated to myopic MH and pediatric RRD.
Accordingly the use of SO is infrequent in primary RRD. SO
is available in different viscosities (1000 and 5000 cs). The
advantage of the 1000 cs oil is easy intra-surgery manipulation
during each injection and extraction. In turn, the advantage of
the 5000 cs oil is its lower ability to enter the anterior chamber
and lower dispersion and emulsification. If the aim is to extract
the oil in a few weeks, the 1000 cs should be enough, although
some authors prefer the 5000 cs SO in all cases because it associates a lower number of complications even though its extraction is slower. The toxicity of SO does not depend on viscosity but on its degree of purification.

Post-surgery positioning
The treatment of RRD tears in the inferior quadrants exhibited differential characteristics compared to the rest of the tears. The traditional postulate was to use a longer duration buffer or the association of a circumferential procedure for treating inferior tears in RRD to enable the cicatrization of the tear edges during the post-surgery period. However, various studies published in the past 5 years have demonstrated that an extensive dissection of the cortical gel and the base of the inferior vitreous enables treating inferior tears without strict post-surgery positioning and with short duration buffer, thus reducing post-surgery mobility without modifying the primary and final reapplication rate.51-53

Pneumatic retinopexy
The main indications for these phakic detachments with transparent media, single or grouped multiple tears located at posterior 8 o’clock without VRP. In this technique the identification of tears prior to surgery is crucial as well as establishing the extension of the hyaloïd detachment and ensuring patient cooperation. In addition to the selection of cases, a significant limitation involves the creation of iatrogenic tears as well as the rate of re-detachment and VRP.54

The anatomic and functional results are inferior in the treatment of pseudophakic primary detachments as compared to phakic RRD.54-57 The primary reapplication rate was of 67-69%,56-59 to 36-37%.54-55 The final reapplication rate in said studies ranges between and 93% and 98%.

The main post-surgery complications are higher rates of VRP of up to 24%,55,57,58 and the presence of an inferior retina re-detachment due to the formation of new tears.60

Special situations
Patients intervened of refractive surgery
Published studies demonstrate the lack of higher retina detachment incidence among patients intervened with LASIK or phakic lens implant when the refractive technique has been carried out without difficulties.61-63 The choice of the surgical technique will depend on the characteristics of each detachment and patient. The efficacy of each technique does not seem to vary in this group of patients.61-63

Recently it was published that scleral surgery in myopia Magnus patients with phakic lens reduces the anterior chamber depth.64

Patients with unidentified tear in the presurgery evaluation
In some cases, even with an exhaustive exploration, it is not possible to identify the primary tear in 2.2-22.5% of patients with primary RRD.26,66 When the primary tear is not identified before or during surgery, the primary reapplication rate is lower compared to the cases in which the tears are identified in the presurgery exploration.26,66 In order to identify the primary tear that could not be identified in the presurgery period, trypan blue with retinotomy has been described in the literature in an attempt to identify the tear, both in primary cases as well as in re-detachments.65,67 The main limitations of this technique are possible retinal and subretinal toxicities caused by trypan blue, the execution of a retinotomy and the difficulty in observing the passage of the dye through small tears that are surrounded by vitreous gel. A recent article has described the role of independent lighting systems, the execution of a dynamic scleral depression and a meticulous dissection of the base of the vitreous in order to identify said tears during surgery.68 The objective of this technique is to apply the sub-retinal fluid distribution patterns described by Lincoff in the presurgery evaluation or during surgery in order to identify the primary tear which, in the vast majority of cases, has a size smaller than ¼ of a papilla.69

Patients with vitreoretinal proliferation grade C (complex retina detachment)
Primary retinal detachment with VRP grade C or above are infrequent, accounting for about 5% of all primary cases in our environment. In the majority of these cases, the primary retinal detachment evolution time exceeds 2 weeks.70 In this clinical situation the expandability of the retina is reduced and invariably associates signs of anterior and posterior VRP. Since the publication of the prospective multicenter study on surgical technique consisting in the association of circumferential procedure with vitrectomy together with the maneuvers required to enable adequate adaptation of the tear edges a general consensus has been reached. In these cases, the tamponade agent is of long duration, C2F6 or SO, which demonstrated clear superiority over short duration tamponade agent.71,72

Giant tear
Vitrectomy techniques constitute the treatment of choice for this pathology. However, the primary reapplication rate is lower than that of the remainder of primary cases.73 The association of circumferential procedure, the execution of 360° photocoagulation, the utilization of liquid perfluorocarbon (LFFC) and the selection of the tamponade agent are the main points of the controversy. In-depth dissection of the vitreous base and the treatment of secondary tears are the essential steps of this surgical technique.

Levels of evidence
- Phakic RRD.
- Noncomplex.
  - Scleral surgery is recommended preferentially over vitrectomy: evidence level 1/recommendation grade A.
  - Scleral surgery is recommended over pneumatic retinopexy: evidence level 1/recommendation grade A.
- Complex.
  - Vitrectomy with circumferential procedure and long duration tamponing agent. Evidence level 1/recommendation grade A.
- Pseudophakic RRD
- Noncomplex.


• Vitrectomy techniques are recommended preferentially over scleral surgery: evidence level 1/recommendation grade A.
• It is recommended to associate circumferential procedure to vitrectomy: evidence level 1/recommendation grade A. No differences were found when associating scleral procedure to vitrectomy: evidence level 2/recommendation grade B.
• Complex
  • Vitrectomy with circumferential procedure and long duration tamponading agent: evidence level 1/recommendation grade A.
  • RRD without tear diagnosed in the presurgery evaluation.
  • Vitrectomy without circumferential procedure with exhaustive dissection of the vitreous base. Evidence level 3/recommendation grade C.
• Giant tear
  • Vitrectomy without or with circumferential procedure. Evidence level 1/recommendation grade A.
  • 360° photocoagulation: evidence level 4/recommendation grade D.
  • Use of long duration tamponade agents: evidence level 1/recommendation grade A.

Failure and relapse of rhegmatogenous retina detachment with and without vitreoretinal proliferation

In recent decades a marked tendency has developed favoring PPV as the first surgical option in the treatment of RRD, in detriment of classic surgery with episcleral explant suture and pneumatic retinopexy. The choice of adequate treatment is a highly specific decision considering the heterogeneous nature of the pathology and variables such as number, size and location of the tears, the presence of VRP, the degree of media opacity, myopia Magnus and the condition of the lens, among others. Within the range of possibilities different clinical trials and prospective randomized studies have been performed in order to determine which surgery is associated to the best anatomic and functional prognostic in specific subgroups of patients with RRD. Of note among said studies is the Silicone Study with its results about eyes with VRP; including cases with prior vitrectomy and/or scleral explants. However, it must be taken into account that virtually all studies were designed to assess primary RRD treatment and not the failure of RRD surgery or relapse. In what concerns the results obtained with the primary treatment, the rate of RRD failure or relapse could be below 5% in selected non-complicated cases, while at the other extreme percentages in the area of 50% can be found in RRD cases complicated mainly by the presence of advanced VRP. As can be appreciated, the range of patients that would require at least 2 surgeries to achieve a definitive retina reapplication is very broad and it must be emphasized that there is a small percentage of patients in which this objective is not achieved.

One of the observed difficulties was the absence of a clear definition of surgical failure and relapse for RRD. In fact, these terms overlap in many cases or are utilized almost as synonyms. In this paper, RRD relapse would be defined as a partial or total detachment that appears after achieving complete retina reapplication, in the absence of internal tamponade agent in the case of vitrectomized eyes. From this definition it can be deduced that the persistence of sub-retinal fluid after pneumatic retinopexy or explant and/or episcleral cerclage surgery is considered as surgical failure and not relapse. The same occurs with vitrectomized eyes with persistence of sub-retinal fluid in the presence of SO after the partial or total reabsorption of air or gas utilized as internal tamponade agent.

The different therapeutic alternatives in the case of RRD failure and relapse based on the presence or absence of VRP and the technique used as primary RRD treatment are described below. The therapeutic alternatives included in this guide for RRD surgical failure or relapse should be considered as a recommendation on the basis of the degree of available scientific evidence. Even though the extrapolation of primary RRD treatment results to re-treatments could have a firm theoretical basis, the interpretation thereof should be cautious due to the possible differences between studies cases and each re-detachment case.

Detachment failure or relapse in eyes without vitreoretinal proliferation

Pneumatic retinopexy
In the RRD cases in which the first therapeutic option was pneumatic retinopexy a primary reapplication rate of 60–80% has been observed in selected cases. The persistence of detachment in the remaining 20–40% of cases occurred predominantly due to the persistence of the vitreoretinal traction in relation to the initially present tear/s, which translated into insufficient retinopexy and subretinal fluid persistence. It could also occur due to the presence of tears that were not initially diagnosed or to inadequate bodily posture. A further cause of failure and relapse of RRD after pneumatic retinopexy is the appearance of new tears after the intravitreal injection of gas (between 7% and 22%). These lesions are located mostly in the inferior quadrants. Regardless of the cause of RRD failure or relapse, this situation usually arises within the first 4 weeks after the initial pneumatic retinopexy.

It is important to mention that in eyes in which pneumatic retinopexy has failed as a primary RRD treatment, the execution of a second pneumatic retinopexy would be associated to an even higher surgical failure rate (23% and 38% respectively). Accordingly it does not seem recommendable to carry out more than one procedure of this type. In case of RRD failure or relapse it would be reasonable to carry out a PPV. In selected cases extrascleral surgery could be considered although there is no sufficient evidence to recommend either option in the absence of VRP. A further option, mainly in cases with new inferior tears, is circumferential cerclage with PPV.

Extraescleral surgery
In general, between 12% and 45% of patients with RRD who were initially treated with extrascleral surgery would require more than one intervention to achieve retina reapplication. The most frequent causes of retina detachment persistence are inadequate positioning of the explant and scleral indentation which does not match the
location of the lesions, the presence of open or fish mouth tears and the presence of untreated retinal tears. In what concerns relapses, these occur within the first 2 months, the most frequent cause being the presence of VRP. Accordingly, RRD relapse in the absence of VRP should lead to the suspicion of an open tear and/or new tears, which could be treated with an explant assessment, the addition of a new explant or vitrectomy. There is no sufficient evidence to recommend either one of these procedures.

In patients with RRD treated with episcleral explant in which sub-retinal fluid was not drained, sometimes the persistence of this fluid can be observed even though the surgery appeared to have been performed correctly. If the indenation of the explants is in relation to the detachment lesions and the subretinal fluid does not compromise the macular area, one of the following approaches could be assumed: a) observe; b) supplement with pneumatic retinopexy; c) make a laser barrier around the fluid; d) carry out PPV, or e) evaluate and replace the explants. These alternatives are discussed below.

Observation. This approach should be adopted only with patients in whom the fluid does not progress, have a clearly defined subretinal fluid of reduced extension and who can understand the situation and are able to commit to regular evaluations. In some RRD, the residual fluid could be reabsorbed slowly.

Supplementary pneumatic retinopexy. Pneumatic retinopexy has been described as an alternative in cases in which the explant is well located but the tears remain open and without efficient retinopexy, in tears located in the upper quadrants. This technique entails the risks inherent to pneumatic retinopexy and has been associated to a definitive reapplication of the retina in up to 75% of cases in the absence of posterior and/or anterior VRP grade C. Laser barrier. In cases in which fluid persists with an RRD area in a convex architecture adjacent to the explant, a laser barrier surrounding it completely has been described as an option to avoid its progression and possible macular involvement.

Explant evaluation. The objective is to increase or modify the indenation architecture in order to close all tears.

Vitrectomy. Vitrectomy should be performed in cases where a fluid persistence is not advisable or there is a high risk of progression towards the macular, and a decision was taken against the above options.

Finally, with the indication of explant extraction in the presence of a totally applied retina, retrospective studies have described retina re-detachment in 2–9% of cases. Accordingly, it is recommended to carry out an exhaustive exploration of the retinal periphery and retinopexy areas before taking the decision to remove the scleral explant.

Pars plana vitrectomy with and without cerclage
The most frequent cause of failure in treating RRD by means of PPV in the absence of VRP is the presence of untreated tears. Tears caused by the entry ports of our instruments should also be suspected. Other causes of PPV failure are insufficient internal tamponade or non-compliance of the prescribed posture.

The SPR study46 observed a greater risk of re-interventions in phakic patients with RRD not complicated by VRP grade B or C treated with PPV in the primary intervention, while in pseudophakic eyes the risk associated to this technique was significantly lower.41 These differences may possibly be due to insufficient treatment of the peripheral retina in an attempt to avoid touching the lens due to the presence thereof.

In any case, treating PPV failure in eyes without VRP involves a new PPV with carefully internal evaluation. Internal tamponade would largely depend on the type of lesions. In phakic eyes, inferior holes and obese individuals or those having difficulty with keeping the posture, circumferential scleral explant with vitrectomy can be considered.

**Detachment failure or relapse in the presence of vitreoretinal proliferation**

The presence of VRP is the main cause of failure in RRD surgery, either in eyes treated for the first with classic surgery or with PPV. In these eyes, the VRP diagnostic is important not only to determine the most adequate therapeutic decision; it also has an implication in what concerns the visual prognosis because only 11–25% of cases will achieve a final visual acuity equal or better than 20/100.72,75,86,88

According to the Silicone Study results, in non-vitrectomized eyes and with VRP not lower than grade C3 (Retina Society Classification, 1983)83 treatment with vitrectomy and internal tamponade with SF6 is not recommended as it associates a lower rate of retinal reapplication and poorer final visual acuity in comparison with AS.72 This statement is also valid for vitrectomized eyes with re-detachment and VRP.

In non-vitrectomized eyes with severe VRP, the use of C3F8 was related to slightly higher retinal reapplication than with the use of SO, with the final visual results being equivalent with both tamponade agents. In the initially described analysis, eyes previously submitted to vitrectomy and internal tamponade with gas did not appear to exhibit significant differences in what concerns the anatomic and visual success applying SO or C3F8 in the following intervention.75 However, a subsequent analysis revealed greater benefit of SO over C3F8 in eyes with severe anterior VRP. In fact, eyes with vitrectomy history prior to inclusion in the study were precisely those which developed this complication with greater frequency.

In eyes with severe VRP with or without previous vitrectomy, RRD failure or relapse was observed in 54–65% of cases.75 In this type of eyes, regardless of the number of re-interventions, total retina reapplication was described in 55–71% of cases.75 Even though multiple interventions are related to lower final visual acuity, the antecedents of RRD failure or relapse after vitrectomy with gas does not seem to influence the end results in the context of the Silicone Study.81 These results were obtained in a population excluding phakic, pseudophakic and aphakic patients in the presence of scleral explant in 73–98% of cases (prior to vitrectomy in non-vitrectomized patients or prior to the re-intervention in vitrectomized patients).
Retinal reattachment does not depend on treating the lesions and the tamponade associated with vitrectomy. In eyes with VRP careful dissection of the vitreous base is essential, as well as adequately releasing the attractions, peeling the epiretinal membranes, eliminating subretinal tractions and applying retinotomy or retinectomy in cases where retinal contraction does not allow an adequate “stretching” of the retina. In non-vitrectomized eyes in which it is necessary to carry out retinotomy, internal tamponade with SO is associated to a higher rate of retinal reapplication, higher final visual acuity and significantly lower ocular hypotony rates in comparison with the use of C$_2$F$_6$.92

In vitrectomized eyes without associated explant, adding cerclage in future interventions due to re-detachment has not been assessed, although an experimental study observed that the presence of a scleral explant could hinder SO tamponade in the area adjacent to the peripheral indentation whereas an inferior explant could enhance internal SO tamponade.93 Explant is useful in the case of re-detachment to compensate the lack of retinal elasticity because, if retinotomy is performed, it enables the proper apposition of the RPE edge.

Heavy silicones are part of a group of silicones having a specific weight heavier than water which prevents them from floating. Initially, these tamponade substances were related to a higher complications rate such as greater emulsification, greater intraocular pressure and increased inflammation.94 However, the combination of partially fluorinated alkanes and conventional silicones has brought about a new generation of heavy silicone with different weights and viscosities. Within this group, Densiron® 68 could have the advantage of behaving similarly as pure SO but in the reverse manner, i.e., like an inferior tamponade bubble.7 In general, it could be established that the use of heavy silicone would be indicated in RRD failure or relapses with tears in the inferior quadrants complicated with VRP and/or where it is necessary to carry out inferior retinotomy or in the presence of posterior lesions in patients unable to maintain a prone position.95 Even so, the results of the Heavy Silicone Oil Study, a trial comparing Densiron® 68, SO with 1000 cs and SO with 5000 cs in eyes with RRD and inferior VRP96 must be awaited to reach a conclusion.

In what concerns the utilization of adjuvants in patients with established VRP, utilization of 5-fluorouracil combined with low molecular weight heparin in the infusion utilized during FPV does not have any beneficial effect and has been associated to lower final visual acuity in eyes with RRD and applied macula.97,98 Similarly, the use of triamcinolone acetate dissolved in SO in eyes with VRP has not been associated to greater anatomic success.95 As regards oral use of retinoic acid in patients with VRP, there is no sufficient evidence to recommend its use.99

**Extracting the silicone oil**

When extracting the SO, the risk of re-detachment must be taken into account.100,102 Re-detachment could be caused by the presence of initially untreated lesions which were hidden by the presence of SO, the posterior extension of an unnoticed peripheral detachment or the persistence of retinal tractions in the context of VRP. Re-detachment in eyes in which the retina was totally applied at the extraction time has been described in 4–28%.100,103,104 Such a broad range is due to the inclusion of RRD patients with multiple characteristics (giants tears, myopia Magnus, phakic/pseudophakic/aphakic, various VRP grades, presence of explants, etc.), obtained from a highly selected population which excluded all cases in which it was decided not to extract the SO. Retina re-detachment can also occur within a variable period of time, ranging from days to several months105 or even during the SO extraction surgery itself, making it advisable to explore the retina in full detail before ending the surgery in order to treat all lesions.

Of all possible factors that could be related to a greater risk of retinal re-detachment in the absence of SO, possibly the most significant is the antecedent of multiple previous RRD surgeries.85,104

In an attempt to reduce the risk of retinal re-detachment it has been described that performing a 360° laser barrier prior to the extraction could be beneficial. However, these results were obtained on the basis of a series of cases.101,102,106

**Levels of evidence**

Non-vitrectomized **phakic** eyes

With untreated tears in the absence of VRP grade B or C, absence of tears greater than 2 o’clock, absence of tears in the posterior pole and absence of multiple tears associated to detachment areas.

**After pneumatic retinopexy.**

- Scleral surgery (evidence level 4/recommendation grade D).
- Evaluate vitrectomy (evidence level 4/recommendation grade D).

Scleral surgery recommendation based on our experience.

**After classic surgery.**

- Vitrectomy and internal tamponade with gas (evidence level 4/recommendation grade D).
- Evaluate supplementation with pneumatic retinopexy (evidence level 4/recommendation grade D).

Non-vitrectomized **pseudophakic** eyes

With untreated tear in the absence of VRP grade B or C, absence of tear exceeding 2 o’clock, absence of tears in the posterior pole and absence of multiple tears associated to detachment areas.15

**After pneumatic retinopexy.**

- Vitrectomy and internal tamponade with gas (evidence level 2/recommendation grade B).

**After classic surgery.**

- Vitrectomy and internal tamponade with gas (evidence level 2/recommendation grade B).

In the presence of **vitreoretinal proliferation grade B** (pseudophakic/aphakic).
in the infusion solution. In pseudophakic and aphakic eyes it is recommended to use iris hooks.

The evidence level for these maneuvers is of 4, with a recommendation grade of D (Fig. 4).

**Scleral surgery complications**

**Scleral perforation**

Perforation when suturing after the scleral procedure is one of the most important and frequent complications of this surgery. The severity and solution will depend on whether only the sclera was perforated or if the retina was perforated as well.\(^\text{107}\)

Perforation of the sclera – choroids. This perforation normally occurs when the retina is detached in the perforation area, with exit of sub-retinal fluid and usually blood being observed.

It is essential to inspect the retina to ensure the absence of damages. It is advisable to replace the suture, attempting to place the scleral procedure over the perforation.

Perforation of the sclera – choroids and retina. If a retinal tear has occurred the scleral procedure must be placed covering the tear and retinopexy must also be performed over the lesion (Fig. 5).

**Subretinal hemorrhage.** Pressure must be applied immediately over the perforation, trying to position the eye to avoid the hemorrhage going towards the fovea and increasing intraocular pressure to stop the bleeding.

In the case of massive subretinal hemorrhage, it is convenient to evaluate the possibility of performing vitrectomy. The use of LPFC facilitates mobilizing the hemorrhage and the insertion of an infusion cannula enables controlling the intraocular pressure to prevent the progression of the bleeding.\(^\text{109}\)

The use of intraocular gases could be useful to displace subretinal hemorrhages that have affected the fovea.

**Complications of trans-scleral drainage**

**Retinal incarceration.** Retinal incarceration occurs due to intraocular pressure fluctuations during trans-scleral drainage of the subretinal fluid. The retina acquires a concave, dimple-like appearance.

Small incarcerations do not usually develop retinal tears but if they are large ruptures could be caused. The scleral procedure must be repositioned to comprise the incarceration; vitrectomy should be considered.

**Choroidal hemorrhage.** This is the most feared complication when performing trans-scleral drainage of sub-retinal fluid.

If dark red bleeding appear, the sclerotomy must be closed immediately and attempts must be made to increase the intraocular pressure above the systolic pressure. Pressure over the sclerotomy area could also reduce the bleeding.

It is recommendable to position the eye such that the bleeding does not advance towards the fovea. For this reason, nasal sclerotomy is preferable to facilitate draining (Fig. 6).
Fig. 4 – General complications of retina detachment surgery.

Fig. 5 – Scleral perforation management.

Fig. 6 – Choroidal hemorrhage during retina detachment surgery.

Fig. 7 – The second intervention post-surgery period after trans-scleral drainage of hemorrhagic choroidal detachment and retina reapplication.

If the choroidal bleeding is massive, the possibility of a deferred vitrectomy must be evaluated. It is recommendable to drain the hemorrhage after 10–15 days when the blood clot is liquefied. In some cases, SO can be used as a temporary tamponade (Fig. 7).

**Intra-surgery complications of pneumatic retinopexy**

The most frequent complications of this surgical technique are described in the main series with an incidence below 10% of cases.50,108

- Vitreous incarceration.
- Entry of gas into the subretinal space. To avoid this it is advisable to make the injection with the needle as vertical
as possible and applying a moderate injection rate, avoiding multiple bubbles.\textsuperscript{109}
- Iatrogenic creation of new tears. These are generally inferior due to the traction exerted by the gas bubble over the posterior edge of the vitreous base.
- Iatrogenic macular detachments. After injecting the gas, the patient is positioned so that the subretinal fluid drains through the tear instead of going towards the macula. After this maneuver, the patient is positioned in the best posture for tamponading the rupture.\textsuperscript{110}

The above maneuvers have a scientific evidence level of 4 and a recommendation grade of D.

**Intra-surgery complications of vitrectomy**

There are no randomized of controlled studies with different methods for resolving vitrectomy complications. However, there are series of cases and therefore the evidence level is of 4 with a grade D recommendation.

**Suprachoroidal or subretinal infusion**

To avoid this complication it is advisable to use a longer cannula (4-6 mm) and to verify in all cases its condition before opening it.

This complication is more frequent in cases of hypotony, trauma and anterior VRF. At present, its frequency is diminishing due to the use of trocars in the 23 and 25 G techniques. However, a highly oblique positioning of the smaller gauge microcannules to diminish the risk of sclerotomy loss could increase the possibility of choroidal/subretinal infusion.

**Iatrogenic damage on the lens**

This damage occurs in about 3% of cases,\textsuperscript{111} in all cases related to surgeon dexterity.

**Iatrogenic retinal tear**

This is the most frequent intra-surgery complication in vitrectomy, with an incidence estimated to be in the area of 6%.\textsuperscript{111-115} In order to avoid this risk, it is essential to adjust the cutting and aspiration parameters when the surgeon operates close to the retina. In addition, at this point surgeon dexterity and learning curve are very important.

The new smaller gauge vitrectomes (23/25 G) with a smaller opening closer to the tip and which operate at high speed, together with adequate control of the vitrectome opening the working cycle, facilitate operating with greater safety in the vicinity of the retina. The use of LFPC in the posterior pole stabilizes the retina and diminishes the risk while dissecting the base of the vitreous.

**Passage of liquid perfluorocarbon to the subretinal space**

This occurs more frequently with large tears and when the LFPC is introduced quickly and with multiple bubbles with high flow in the vitreous cavity due to loss caused by sclerotomies. It is essential to relax completely traction over the retina so that the LFPC produces only a single bubble and does not displace towards the subretinal space. This complication is managed injecting more LFPC to displace the subretinal LFPC and aspirating it through an existing tear.

Other common complications in any vitrectomy are:

- Choroidal hemorrhage, usually linked to brusque hypotonies or to accidental contact of instruments with the choroids. It occurs more frequently in traumatic and high myopic patients. It could be related to surgeon dexterity.
- Vitreous incarceration.
- Sclerotomy filtering due to poor suture technique, also related to surgeon dexterity (Fig. 8).

**Post surgery complications**

**Diplopia**

In the first 6 weeks after scleral surgery, the incidence of heterotropia is upto 80%. Fortunately, the vast majority of these deviations are temporary and the incidence of permanent post-surgery diplopia is about 4%.\textsuperscript{115} The scleral procedures which are most related to the appearance of diplopia are cerclage and large size implants or explants. Probably, diplopia is a consequence of cicatrizations at the arbitrary level or adherences between the extraocular muscle and the scleral procedures. Additional influential factors could be traumatic damage to the rectal muscles in the insertion of the implant or explant and periocular anesthetic injection.\textsuperscript{116} The
muscle perimysium must not be traumatized during surgery and should not be held with sharp instruments. About half of patients with diplopia present ocular torsion components after scleral surgery. The effects of muscle deinsertion and subsequent reinsertion during scleral surgery over postsurgery diplopia are controversial. Some authors believe that diplopia is much more frequent after mobilizing muscles, above all in the case of the superior and inferior rectals, whereas other authors do not believe there is any correlation between post-surgery to diplopia and muscle mobilization.

The initial treatment is conservative as the majority of cases resolve spontaneously. The surgical approach of these patients is generally difficult because scleral procedures under the muscles prevent muscular recession, and adherences between extraocular muscles and scleral procedures frequently require the explant thereof. As scleral procedures involve special anatomic alterations, the usual surgical principles for strabismus surgery are not applicable. For this reason, generally the treatment of choice is prism therapy. If muscular surgery is necessary, a technique with adjustable sutures should be considered (evidence level 3/recommendation grade C).

**Epiretinal membrane**

The formation of an epiretinal membrane (ERM) is an important cause of vision loss after retina detachment scleral surgery. The cellular elements that make up ERM come from epithelial and retinal glial cells. The incidence of ERM after scleral surgery ranges between 3% and 17%. The risk factors for developing ERM are presurgery VRP grade B or higher, age, the presence of total RRD, vitreous hemorrhage and the loss of the vitreous during subretinal fluid draining. In the pediatric age, the vitreous cortex is tightly joined to the retina. This seems to be correlated, together with the increase of tissue cicatrization. Accordingly children develop post-surgery VRP and ERM with greater frequency than adults. The incidence of ERM after retina detachment in the adult population is estimated to be 3% according to Smiddy et al. In contrast with this percentage, a study carried out by Michels et al. stated that the incidence of ERM relapse in the pediatric population reaches up to 36% (4 out of 11 intervened eyes). Myopic patients have less risk than emmetropic patients. Aphakia, uveitis, the presence of cataracts or the use of implants instead of explants are not risk factors for the development of ERM (evidence level 3/recommendation grade C).

**Macular edema**

CME occurs as a response to any type of intraocular inflammation. The surgical trauma caused by the scleral procedure, subretinal fluid draining, cryotherapy, photocoagulation or diathermia cause significant intraocular inflammation. Therefore, it is not surprising that CME is relatively frequent after RRD surgery.

Fluorescein angiography (FA) has shown that the incidence of CME after RRD surgery is much more frequent than detected by ocular fundus biomicroscopic exploration. Lobes and Grand observed an angiographic incidence of 43% of CME after RRD scleral surgery. In 50% of eyes, CME resolved spontaneously one year after surgery. The final visual acuity was 0.4 better in 83.3% of eyes with temporary CME.

The course of CME after RRD surgery is comparable to that which follows cataract surgery. In 75% of cases, CME resolved spontaneously in a period under 2 years. On most occasions, CME delays the recovery of the best visual acuity after surgery. However, the prognostic of CME is not clear when it does not resolve within 2 years after surgery.

Aphakic eyes have a greater incidence of CME after RRD surgery, reaching up to 60%. Age above 55 is also correlated to CME development even though the macular application condition or subretinal fluid drainage (or lack thereof) do not seem to increase the risk of this complication.

At present, OCT is utilized more than FA for detecting CME. In 2009, Wakabayashi et al. detected a frequency of CME after retina detachment surgery within a broad range of post-surgery time of 10.3 ± 7.3 months by means of FD-OCT of 4%, with 11% of patients exhibiting residual subretinal fluid, 23% exhibiting ERM and 43% disruption between the internal and external layer of the photoreceptor segments (evidence level 3/recommendation grade C).

**Macular holes**

Secondary MH appearing after RRD surgery were initially described by Brown et al. and subsequently associated to cases treated with pneumatic retinopexy and VPP. The prevalence of MH ranges between 0.5% and 1%. The pathogenicity is unknown although probably the presence of long-lasting ERM or CME could facilitate their appearance. The same surgical treatment that is efficient for idiopathic MH achieves good anatomic results in these MH with functional results dependent on the previous RRD history (evidence level 3/recommendation grade C).

**Retention of subretinal liquid perfluorocarbon**

Subfoveal LPFC is a rare but significant complication of vitreoretinal surgery which occurs with a frequency of 0.9%. It courses with absolute central scotoma which can resolve when extracting the LPFC. In the few cases described in the literature the LPFC has remained for variable periods of time without influencing the final visual result. The visual prognosis is relatively good and does not depend on patient age or time of permanence in the subretinal space even though 3 months evolution have elapsed. Accordingly, in one of the best cases of the studied series, Roth et al. maintained LPFC for 180 days in one of their patients and the final visual acuity was of 20/30. Various sub-retinal cannules have been utilized for extracting subfoveal LPFC but the safest system is a 50 G glass micropipette which easily goes through the retina and induces a minimum of iatrogenia and in addition does not require sealing of the extraction point.

LPFC bubbles persisted in the vitreous cavity of 1–11% of patients who received LPFC during the surgical procedure. In general said bubbles are tolerated and have no deleterious effects. However, if greater amounts of LPFC persist in the vitreous cavity, it can be phagocytosed by macrophages that may produce sedimentation over the lens, the ciliary body...
and the peripheral retina. In aphakic patients direct contact of LPFC with the endothelium can cause endothelial cell loss. If small amounts of LPFC persist in the anterior chamber, it is advisable to extract it through the limbus (evidence level 3/recommendation grade C).

**Persistent subfoveal fluid**

Some patients successfully intervened for RRD exhibit in OCT sub-clinic subfoveal fluid. This finding was initially described by Wolfensberger et al. and appears in OCT as a hyporeflective area below the fovea and in other cases below the fovea and the adjacent retina (localized and diffuse subfoveal fluid, respectively). When these patients are followed up, the fluid was observed to gradually diminish, sometimes accompanied by visual acuity increase.

In a series of 53 RRD (panel communication, American Academy of Ophthalmology, Orlando, 2003), the presence of subfoveal fluid one month after the intervention was of 34%, gradually diminishing to 11% after 12 months (Fig. 1). No relationship was found between the appearance of this fluid and the duration of the macular detachment. Similarly, no differences were found in visual acuity evolution between patients with and without fluid during the follow-up, and the disappearance thereof was not accompanied with visual acuity increase. In contrast, the presence of subfoveal fluid was related with the height of the macular detachment, the frequency thereof being of 45% in bullous RRD (over 1000 μ) and of 15% in RRD under 1000 μ (p = 0.036) (evidence level 3/recommendation grade C) (Fig. 9).

**Traumatic retinal detachment**

Ocular trauma is one of the main causes of ocular morbidity and the most important cause of monocular vision loss. Children and young adults constitute the main risk group. Ocular traumatisms are described according to the standardized classification of the International Society of Ocular Trauma and the American Academy of Ophthalmology (Table 2). Both the closed and penetrating types of ocular trauma can produce retinal tear due to direct retinal perforation, concussion or vitreous traction. In addition, fibrocellular proliferation which occurs in the lesion after the traumatism can produce vitreoretinal traction with the ensuing detachment. Traumatic retinal detachments accounts for 20% of all detachments in phakic patients (Table 3).

**Retina detachment due to closed ocular traumatism**

Pathogeny

Closed traumatisms produce retinal tears due to two types of direct concussion of the ocular globe: impact adjacent to the traumatism point, and counter-impact which is opposite the traumatism point. Closed traumatism compresses the eye along its anterior-posterior diameter and expands it along the equatorial plane. High-speed videophotography studies have demonstrated a reduction of the anterior posterior axis of 60% followed by a hyper extension of 112%. The quick compression of the ocular globe produces traction on the base of the vitreous, giving rise to predominantly equatorial retinal tears, retinal dialysis, MH and avulsion of the vitreous base. The most frequent location of these lesions is the inferior temporal quadrant as the orbital bones provide very little protection and also due to Bell’s phenomenon.

Lesion types and treatment

Retinal dialysis (Fig. 10) is the most frequent lesion, observed in 84% of retina detachments due to concussions. It usually progresses slowly in what concerns onset and symptoms as it generally occurs in young patients without vitreous syneresis. Accordingly, the accumulation and progression of subretinal fluid is slow and pigmented and parallel retina detachment lines can be observed which signal the various stages of detachment progression. Treatment of traumatic dialysis is surgical, inserting circumferential scleral indentation procedure in the dialysis area, cryotherapy or diode laser associating sub-retinal fluid drainage if its volume is large (evidence level 4/recommendation grade D). Prognosis is excellent, with retina reapplication rate in the area of 87–94%.

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**Table 2 – Treatment of post-surgery complications.**

<table>
<thead>
<tr>
<th>Post-surgery complication</th>
<th>Treatment</th>
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<tbody>
<tr>
<td>Diplopia</td>
<td>Observation</td>
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<tr>
<td>Macular epiretinal membrane</td>
<td>Observations</td>
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<tr>
<td>Macular edema</td>
<td>Prisms</td>
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<tr>
<td>Macular hole</td>
<td>Strabismus surgery with adjustable sutures</td>
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<tr>
<td>Persistence of subretinal liquid perflurocarbon</td>
<td>20/25 G vitreoretinal surgery</td>
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<tr>
<td>Persistence of subfoveal fluid</td>
<td>Medical treatment (acetazolamide)</td>
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<tr>
<td></td>
<td>Intravitreal triamcinolone</td>
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<td></td>
<td>Vitrreotinal surgery + dissection MLI + gas 23/25 G</td>
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<td></td>
<td>Vitrreotinal surgery with subretinal 50 G cannule if it consists in foveal area</td>
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</tbody>
</table>

**Table 3 – Standardized ocular traumatism classification.**

<table>
<thead>
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<th>Ocular traumatism classification</th>
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<td>Open ocular globe (wound comprising total ocular wall thickness; cornea or sclera or both)</td>
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<tr>
<td>Rupture</td>
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<tr>
<td>Tear</td>
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<tr>
<td>Penetrating (one-point entry, no exit wound)</td>
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<tr>
<td>Perforating (separated entry and exit wounds caused by the same element)</td>
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<tr>
<td>Intraocular foreign body (retained foreign body that caused the entry wound)</td>
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<tr>
<td>Closed ocular globe</td>
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<tr>
<td>Concussion</td>
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<td>Laminar tear of the eye wall</td>
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Giant tears\textsuperscript{146} (90° extension or more) (Fig. 11) have a prevalence of 8% as cause of concussion traumatism retina detachment. In these patients, immediate surgery is important due to the large exposed RPE surface and the frequent association of vitreous hemorrhage.

In addition, the trauma induces hematoretinal barrier rupture and inflammation, which means that all the VRP pre-disposing factors are present. The surgical technique includes vitrectomy, insertion of a scleral procedure to relax the vitreous base, use of LPFC and lensectomy depending on the association or not of traumatic cataract and/or lens dislocation or sub dislocation\textsuperscript{144} (evidence level 4/recommendation grade D).

The utilization of broad field visualization systems and the development of new instrumentation techniques have significantly improved the anatomic success in these patients. Preferably, the posterior edge photocoagulation of the giant tear must be made after carrying out an exchange with tamponade agent because during the exchange it is possible to observe a discrete displacement of the tear posterior edge. It is convenient to reinforce the horns of the tear because that is generally where it can reopen, as well as eliminating the anterior retina because it has no blood supply and will necrotize and thus contribute to increase intraocular inflammation. In
what concerns tamponade agents, it is preferable to use SO in cases with inferior giant tears or those exceeding 270°, in children (evidence level 4/recommendation grade D) and in cases with signs of advanced VRP (evidence level 1/recommendation grade A).

In 5% of traumatic concussion retina detachment cases we found rounded holes as a cause and in the remaining 3% horseshoe-shaped tears (Fig. 12). It is important to emphasize that 28% of traumatic concussion retina detachment cases occur in myopic patients.

Retina detachments in open ocular traumatism

Pathogen

Open ocular globe lesions can course with intraocular blood, lens particles in the vitreous cavity, infection, intraocular foreign body and inflammatory infiltration. All these factors disrupt the hematoretinal barrier, releasing various chemotoxins, inflammatory cytokines and growth factors that induce cellular proliferation and migration in order to initiate cicatrization. Said cells have contracting properties and when they become organized the contraction forces they are able to generate can exceed the physiological stress that maintains the normal adhesion of the retina to the RPE. This cicatrization process is the main pathway that leads to retina detachment due to traction and to the development of VRP in penetrating ocular traumatism.

Basically, there are 2 mechanisms for producing tractional retina detachment: the vitreous is incarcerated in the injury and the growth of fibers from the injury along the vitreous cavity produces traction over the base of the vitreous and the peripheral retina²⁷ (Fig. 13). The other proposed mechanism occurs due to contraction of the epiretinal fibrous tissue on the surface of the peripheral and equatorial retina, causing a shortening thereof. Generally both mechanisms combine to produce tractional retina detachment.

The frequency of VRP varies according to the type of traumatism, being more frequent in perforating and then

![Fig. 12 – Post-traumatic equatorial tears due to concussion caused by fist impact. Note the nearly pathognomonic appearance of the traumatic tear, i.e. the disarrayed edges with signs of VRP due to rolling up of the edge.](image1)

![Fig. 14 – Open trauma due to perforation caused by a projectile which has caused anterior and posterior scleral tear. The visual acuity at the evaluation was only perception of light (sign of a poor prognosis).](image2)

![Fig. 13 – The vitreous is incarcerated in the entry and exit points, fibers proliferate towards the vitreous cavity and produce traction, giving rise to tears in the peripheral retina.](image3)
penetrating wounds, in the simultaneous involvement of the anterior and posterior segments, in the vitreous prolapse, in wounds exceeding 10 mm length and choroidal hemorrhage.

Treatment
Surgical closure of the ocular penetration should restore as much as possible the anatomy of the ocular globe, avoid complications and repair the eye for subsequent interventions\textsuperscript{148} (Fig. 14). There is controversy about the most adequate time to perform vitrectomy.\textsuperscript{149,150} While some authors proposed to perform it in the first 48 h, others maintain that surgery should be deferred up to 72 hours in order to reduce the risk of choroidal bleeding.

The objectives of the surgical procedure include placing a provisional keratoprostheses, preferably of the Eckard\textsuperscript{151} type, in cases with corneal opacity, cataract extraction, lens sub-dislocation or dislocation\textsuperscript{152} and insertion of an infusion cannule, preferably with lighting, in an area where the sclera is in good condition far from the penetration area. The use of independent light systems such as the Chandelier\textsuperscript{\textregistered} 25 G xenon light (Synergetics USA Inc., O'Fallon, MO, USA), together with the use of broader field visualization systems, will allow a better approach to vitrectomy in these cases.

In most occasions a scleral procedure is associated to relax the base of the vitreous. The surgical approach of vitrectomy includes cleaning the hemorrhage and vitreous opacities, extraction of the cortical vitreous, releasing traction at the entry point, exploring the periphery by means of dynamic scleral depression, dissection of the posterior hyaloids, bi-manual dissection of VRP, use of LPFC for reapplying the detached retina,\textsuperscript{153} performing in necessary cases relaxation retinotomy and diode laser retinopexy of all retinal tears. In cases exhibiting subretinal hemorrhage, the blood can be extracted through anterior displacement by means of LPFC, draining at the periphery through a retinal tear or retinotomy. The characteristics of each case will determine the need of a long duration tamponade element such as gas or SO\textsubscript{2}.\textsuperscript{74} In eyes with signs of massive VRP or anterior traction that requires retino-

Fig. 15 – Retina detachment secondary to penetrating ocular traumatisn.

Fig. 16 – Complete reapplication of the retina extended with LPFC and applying silicone oil tamponade. Indentation procedure at 360° was associated.

Fig. 17 – Retina detachment in ocular perforation with incarcerated retina at the point of entry.
Fig. 18 – Bimanual dissection of epiretinal proliferation to release traction.

Fig. 19 – In cases where traction persists, retinotomy is performed.

Fig. 20 – Subretinal proliferation and post-surgery appearance.
Conflict of interests

No conflict of interest has been declared by the authors.

REFERENCES


Fig. 21 – Dissection of subretinal fibrosis: nasal axis retinotomy and dissection.

persists and is located close to the macula, bimanual retinotomy is performed keeping it as reduced as possible (Fig. 19). In retina detachment cases with associated subretinal fibrosis (Fig. 20), generally reappllication is not prevented unless it exhibits a closed circumferential ring configuration or it is contracted. In these situations, extraction is indicated. The usual procedure is superior nasal axis retinotomy and subretinal proliferation dissection (Fig. 21).

The main factors to be taken into account in traumatic retinal detachment are their severity and complexity when compared to idiopathic retina detachment, as well as early treatment and the difficulty involved in surgical treatments. Even so, improvements have been achieved in the visual prognosis for these patients with the newest techniques and instruments. But despite said improvements the end functional deficit in these patients continues to be high.


