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Surgical techniques in retinal detachment: scleral buckling vs circumferential + buckling

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Abstract

The goal of surgery for retinal detachment is to repair the detachment obtaining the best results and the minor complications. In cases where retinal rupture has caused excessive subcutaneous fluid accumulation, scleral buckling / circumferential techniques or vitrectomy are adopted. In most cases, scleral buckling resolves retinal detachment anatomically and functionally within one month
The aim of the study is the evaluation of efficacy and postoperative complications in a group of patients with non complicated rhegmatogenous retinal detachment treated with circumferential and buckling techniques, compared to the control group, treated with buckling alone.
Fifty-three patients aged between 37 and 82 (mean age: 58.9 years) with rhegmatogenous retinal detachment were recruited from January 2005 to March 2010. Group A patients undergone radial buckling. Patients in group B were subjected to circling with silicone band (circumferential + buckling) application. The safety of the two surgical techniques was evaluated in terms of intra and postoperative complications.
The results showed that both techniques are effective in treating rhegmatogenous retinal detachment. The surgery "ab externo" was successful for the treatment of retinal detachment after first intervention in 96% of cases in Group A and 75% of patients in Group B. The best manageability of the circumferential and buckling technique has avoided the development of intraoperative complications. However, the number and type of postoperative complications would indicate that the circumferential + buckling technique should not be adopted unless it is strictly necessary.
In light of the data obtained, we can state that both surgical techniques are effective in determining retinal adhesion to the retinal pigment epithelium following rhegmatogenous retinal detachment. However, the use of buckling (minimal episcleral surgery) is safer and guarantees a better outcome on the patient visual acuity, and is therefore preferable to the circumferential + buckling.

Keywords: *Retinal detachment; Rhegmatogenous; Buckling; Circumferential; Surgery; Complications*

Introduction

Retinal detachment is the separation of the neurosensory retina from the pigmented retinal epithelium, caused by the loss of the forces holding the retina to this epithelium [1] (Michels et al., 1990). The detachment leads to a subretinal fluid accumulation in the virtual space between the two sheets.

There are four main types of retinal detachment: rhegmatogenous; tractional; exudative or secondary; and

combined (tractional - rhegmatogenous) [2] (Hilton et al., 1995). Rhegmatogenous retinal detachment is an all thickness defect in the sensory retina that allows the fluid derived from the synthetic vitreous to gain access to sub-retinal space [3,4] (Mitri and Charteris, 2010; Kanski, 2007).

In any type, the goal of surgery is the anatomical and functional visual recovery with the slightest trauma and minor complications [5] (Kreissig, 2004).

Scleral buckling is an "ab externo" surgical procedure [6] Wolff, 2015) in which the sutured material on the sclera (exoplants) creates an indentation inward. It is used in the treatment of rhegmatogenous retinal detachment [7] (Kim et al., 2016), in order to close the retinal ruptures by attaching the retinal pigmentary epithelium to the neurosensory retina and loosening the vitreoretinal dynamic traction at the site of the local vitreoretinal adhesion [8] (Grizzard et al., 1994).

The explants are made of silicone, rigid or soft. The retinal rupture should ideally be surrounded by at least 2 mm of buckling, so the size of the explant is fundamental. It is also important that buckling involve the area of the frontal vitreous base until the rupture, to prevent the risk of subsequent reopening and anterior subretinal fluid leakage.

Buckling can be radial or segmental circumferential [9] (Banaee et al., 2009). In detachments that require circumferential buckling, the greater the length of the buckling, the higher the probability of the development of radial folds. For this reason, it is preferable to keep the circumferential buckling as short as possible. Thus, the technique of minimal episcleral buckling has evolved and is currently one of the therapeutic options in the primary rhegmatogenous retinal detachment [10,11] (Kreissig, 1989; Kreissig et al., 1992).

This technique, performed in local anesthesia [12] (Pacella et al., 2013), is indicated in the case of primary retinal detachments caused by one or more breaks [8] (Grizzard et al., 1994). It consists in the application of cryopexy on the rupture, under ophthalmoscopic control, and a sponge, preferably in the radial direction. The sponge dimension is determined solely by the size of the rupture (s), and not by the extension of the retinal lift.

It has been highlighted by some authors that in 50% of rhegmatogenous retinal detachment retinal rupture is unique, and in most cases multiple ruptures are not distributed over the entire retinal circumference but tend to be localized within the primary breaking quadrant [3, 13] (Mitri and Charteris, 2010; Takkar et al., 2016). These data contributed to favor the application of the minimum retinal indentation in place of encircling in most cases of rhegmatogenous retinal detachments.

Circumferential techniques is a surgical technique introduced for the first time by Schepens in 1957 [14] and Arruga in 1958 [15], which uses a circular silicone system of a width of some millimeters (usually 2 to 7, based on the directions) that is fixed to 360° on the sclera, behind the equator. In this way, the choroid is brought closer to the raised retina, changing the shape of the eye.

This modification of the form is able to reduce vitreous traction and consequently increases the buffing strength of the vitreous. It also allows to create a new “ora serrata” and to exclude any proliferation occurring peripherally to the indentation. Thanks to this possibility, it extends the number of retinal detachment patients treated by "ab externo" surgery.

The technique involves numerous variants, to increase the possibility of retinal adhesion (association with rubber sponge or silicone in the circumferential + buckling), to repair the associated retinal ruptures (cryopexy or laser photocoagulation), and to increase the speed of removal of subretinal fluid (evacuation puncture) [16-18] (La Heij et al., 2000; Tornambe and Hilton, 1997; Malagola et al., 2015).

As evidenced, there is currently no single technique for treating any form of retinal detachment. The procedures described are all intended to close the retinal rupture that has caused retinal detachment that would cause a recurrence if not well sealed. The purpose of this study is to evaluate the safety and efficacy of buckling surgery with respect to the circumferential+ buckling in rhegmatogenous retinal detachment therapy.

Both techniques offer success rates equal to or greater than 90% success after first intervention and close to 100% after second intervention, but significantly differ in follow-up at two years. Therefore, the object of the study is the evaluation of postoperative features in a group of patients treated with circumferential and buckling techniques, compared to the control group, treated with buckling alone.

Materials and methods

Subjects

Fifty-three patients aged between 37 and 82 (mean age: 58.9 years) with rhegmatogenous retinal detachment were recruited from January 2005 to March 2010. The study was approved by the Ethics Committee of the University of Rome “La Sapienza” and was performed in accordance with the ethical standards of the Declaration of Helsinki. A written informed consent was obtained from each patient. All patients came from the Operative Ophthalmic Emergency Unit of the Department of the

Department of Sensory Organs of the Polyclinic Umberto I in Rome.

Inclusion criteria

In order to make the data homogeneous, the following inclusion criteria were used: non complicated rhegmatogenous retinal detachments; retinal ruptures in one or two quadrants; phakic eyes.

Exclusion criteria

The exclusion criteria were as follows: eyes with high proliferative vitreoretinopathy (PVR); giant retinal ruptures; retinal dialyses; posterior detachments (macular hole); multiple retinal ruptures at different latitude; retinal ruptures with circumferential extensions above 70 degrees; post-traumatic retinal detachments; retinal detachments from hemovitreous. In addition, all patients who did not attend all follow-up visits were excluded.

Instrumental examinations

Before surgery, all patients underwent routine examinations. As far as specialist examinations are concerned, total ocular examination was performed at T0 (during hospitalization, prior to surgical treatment), T1 (immediate postoperative), T2 (3 days), T3 (7 days) T4 (15 months), T5 (1 month), T6 (3 months), T7 (6 months), T8 (12 months), T9 (18 months), T10 (24 months).

The following instrumental examinations were executed. Natural and correct visual acuity (VA) evaluation. Biomicroscopic evaluation of the anterior segment by slit lamp. Intraocular pressure assessment (IOP). Evaluation of the eye fundus by direct biomicroscopy with Goldmann lens and indirect biomicroscopy carefully examining the retinal periphery, as the failure to visualize other retinal ruptures or retinal holes beyond that determining retinal detachment would have caused the failure of the surgical 'intervention. Photographs of the eye fundus. Ocular bulb ultrasonography. OCT for a correct evaluation of the macular lifting state.

Experimental groups

All patients were prepared for peripheral anesthesia (0.75% Levobupivacaine) [19] (Pacella et al., 2010). The selected patients were randomly divided into two groups, called Group A and Group B, depending on the type of surgery they were subsequently subjected to.

Group A patients at T0 time undergone radial buckling. Patients in group B were subjected to circumferential with silicone band (circumferential + buckling) application. After surgery, all patients were placed at supine position for 24 hours and were treated with prophylactic antibiotic therapy *per os*.

Group A was composed of 25 patients, including 11 women and 14 men aged between 40 and 82 (mean age: 58.48 years). Group B was composed of 28 patients, including 9 women and 19 men aged between 37 and 78 (mean age: 59.28 years). In Group A, retinal detachment was present in 52% (13 patients) in the right eye, in 48% (12 patients) of the cases in the left eye. In group B, detachment was present in 60.8% (17 patients) of cases in the right eye, in 39.2% (11 patients) of cases in the left eye.

Intra and post- operative complications

The intra and postoperative complications of the two groups were recorded, the latter being divided into early (short-term) and late (mid and long-term). The statistical analyses were performed on the number of complications the patients of the two groups met at different time intervals.

Statistical Analysis

Data are reported as mean and standard deviation. Ages were compared with Mann-Whitney's non-parametric test. Associations were evaluated by Fisher's exact test. All p-value values <0.05 were considered statistically significant.

Results

Clinical examinations of experimental groups

By evaluating the ophthalmologic medical history, 41.5% (22 patients) were already affected by myopia, of whom 36.3% (8 patients) with visus <5 D (high-grade myopia), and 3.7% (2 patients) experienced astigmatism. Objective examination and bulb ocular echography highlighted an initial opacity of the crystalline in 11.3% (8 patients).

At time T0, the studied ocular fundus evidenced in 22.6% (12 patients) a retinal detachment with macular involvement, a parameter used in our study to determine the validity of the two types of intervention.

In details, patients affected by these pathologies at time T0 were randomly divided into the two groups. In Group A, 28% (7 patients) had arterial hypertension, 24% (6 patients) dyslipidemia, and 4% (1 patient) diabetes mellitus. Forty% (10 patients) had myopia, of whom 30% (3 patients) with visus <5 D; 8% (two patients) had crystalline sclerosis, 24% (6 patients) had macular involvement.

In Group B, 42.8% (12 patients) had arterial hypertension, 38.3% (11 patients), dyslipidemia, and 10.7% (1 patient) diabetes mellitus. 42.8% (12 patients) had myopia, of whom 41.6% (5 patients) with visus <5D; 21.4% (six patients) had sclerosis of the crystalline, 21.4 (six patients) with macular involvement.

The results obtained with the Fisher test for comparison with sex (p-value = 0.81 not significant) and with the U-test of Mann-Whitney for comparison with age (p-value = 0.655 not significant) showed that the distribution by sex and by age (Group A: 58.48 ±12.139 years; Group B: 59.29 ±9.741) were comparable.

Short-term intraoperative and postoperative complications

By analyzing short-term intraoperative and postoperative complications (T1-T4) (**Fig. 1**), we found a statistically significant difference between the two groups (p-value = 0.036).

In Group A, 48% of patients experienced a complication and 4% two complications, while in 48% of cases we found no complications. Subretinal hemorrhages, observed in 35% of cases (9 patients) and belonging to intraoperative complications, were also found in the control visits conducted within the first 2 weeks, but spontaneous resorption occurred at subsequent controls.

The presence of subretinal fluid, found in 20% of cases (5 patients), a short-term postoperative complication, required in 80% of cases (4 patients) a re-intervention of buckling repositioning, and in 20% of cases (1 patient) the need to make a circumferential + buckling to permanently close the retinal rupture. For this patient the follow-up was interrupted. Notably, buckling repositioning was correlated to the intrinsic difficulty of the intervention type (minimal episcleral surgery): in fact, the buckling technique, as specified by different authors, has a relatively low learning curve [20] (Sagong and Chang, 2010). Thus, patients operated between January 2005 and August 2007 had subretinal fluid, while there were no cases in which this complication occurred in patients operated in the following months (**Table 1**).

In Group B, we found that 17.9% of patients had a single complication, 25% with 2 complications, and 3.6% with 3 complications. However, in 55.6% of cases no complications were observed.

Retinal detachment (25% of patients, 7 cases) required, as in Group A, a new intervention to resolve retinal detachment. In one case, pneumoretinopexy [17, 21] Tornambe and Hilton, 1997) was required, while in other cases (21.4%, six cases), for the presence of vitreoretinal tractions, pars plana vitrectomy was preferred [22, 23] Heimann et al., 1996; Richardson et al., 2000). Specifically, in one case, vitrectomy was necessary for the development of the most fearsome complication of circumferential, the macular hole [24] Moshfeghi et al., 2013). In these patients, the follow-up was discontinued (Table 1).

Retinal hemorrhages, intraoperative complications secondary to the drainage of subretinal fluid found in 14.3% of the cases (4 patients), occurred a spontaneous resorption.

Table 1. Short-term postoperative complications (15 days post-operation)

Complications	Group A (25 patients)	Group B (28 patients)
Retinal elevation	20%	25%
Macular hole	0%	3.5%
Ocular hypertension	0%	7.1%

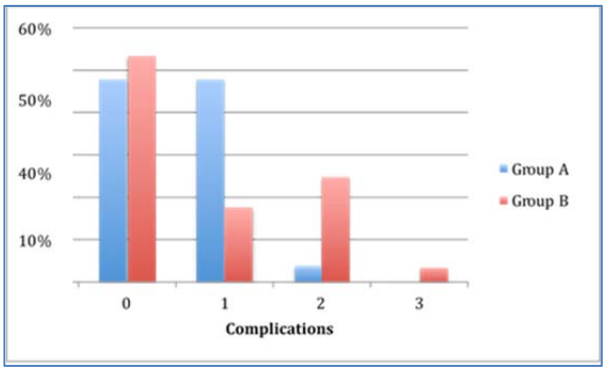


Figure 1. Short-term (15 days post-surgery) postoperative complications in the two groups.

Mid-term intraoperative and postoperative complications

Post-operative mid-term complications (T5-T7) (**Fig. 2**) were thus distributed: in Group A, 24% of patients developed a complication. Specifically, three patients developed a widespread vitreal non-homogeneous heterogeneity non-described at T0; a patient showed a fibrin clot resulting from subretinal hemorrhage reabsorption and in one case, macular pucker was detected (**Table 2**).

In Group B, 25% developed a complication, and 20.8% two complications. The macular pucker, found with the examination of the ocular fundus in T7 in one case, was treated with macular peeling. Retinal pigment epithelium (RPE) dystrophy, found in two cases at T7, was in no way responsible for a significant reduction of visus, involving only the retinal periphery and not the macular region (Table 2).

The cataract development attributable to the operation (3 cases) was evaluated, based on the crystalline conditions at time T0. In the count of complications, those cases of cataracts developed in patients with T0-

crystalline opacity were excluded, because the treatment was not directly implicated in its aetiopathogenesis (Table 2).

The diplopia reported by patients (3 cases) at T6, being a condition due to a trauma in the right muscles during the positioning of the buckling, was also scheduled as intraoperative complication. In all cases symptomatology was absent in T8 (Table 2).

Choroidal detachment, detected at T6 and T7 in three cases, was treated with absolute rest and with steroid treatment, as it was not requiring surgical intervention (Table 2). The ocular hypotone (1 case), found at T6, was treated with SF6 introduction into the vitreous chamber, after the removal of the silicone band (Table 2). Again, we found a statistically significant difference between the two groups (p-value = 0.047).

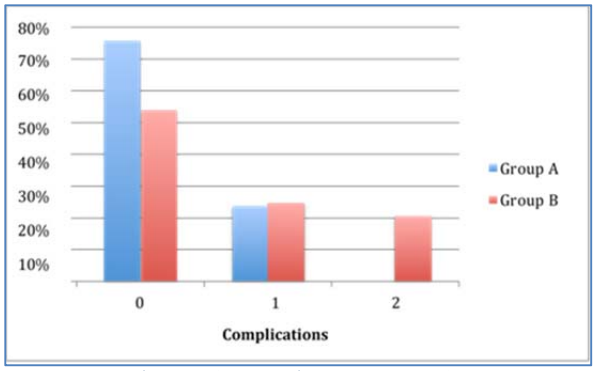


Figure 2. Mid-term (6 months post-surgery) postoperative complications in the two groups.

Table 2. Mid-term postoperative complications (6 months post-operation). Retinal pigment epithelium (RPE).

Complications	Group A (24 patients)	Group B (21 patients)
Macular Pucker	4.15%	4.7%
Vitreal Heterogeneity	12.5%	0%
Fibrin Clot	4.15%	0%
RPE Dystrophy	0%	9.52%
Cataract	0%	14.3%
Diplopia	0%	14.3%
Choroidal Detachment	0%	14.3%
Ocular Hypotone	0%	4.7%

Long-term intraoperative and postoperative complications

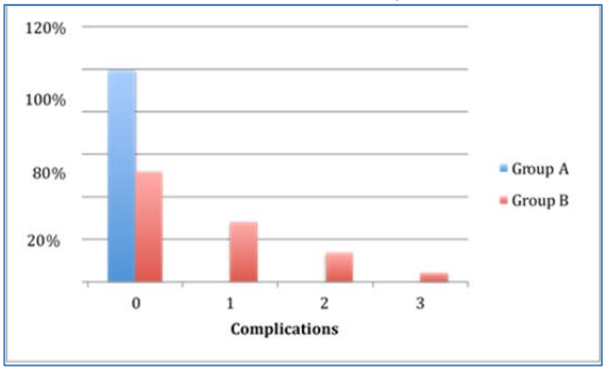
Long-term postoperative complications (T8-T10) (**Fig. 3**) were thus distributed. Group A did not have long-term complications (**Table 3**).

In group B, 28.6% of cases had one complication, in 14.3% of cases 2 complications and in one case (4.8%) 3 complications. Vitrectomy was found in four cases, and in two, there was the association with RPE dystrophy. The RPE atrophy occurred in two cases at T10 (Table 3). The posterior vitreous detachment (PVD) associated with proliferative retinopathy was found in three cases at T8 and T9. The macular pucker was found in a patient at T8, and even this case was treated with macular peeling.

Diplopia was found in two patients, respectively at T8 and T9, but it did not appear in subsequent follow-up controls (Table 3). Myopic chorioretinitis was found in two cases at T9, associated with papillary excavation and proliferative retinopathy in one and PVD in the other case (Table 3).

A highly statistically significant difference between the two groups was found (p-value = 0.002).

Figure 3. Long-term (24 months post-surgery) postoperative complications in the two groups.



Complications	Group A (24 patients)	Group B (21 patients)
Vitreal Heterogeneity	0%	19%
RPE Dystrophy/Atrophy	0%	19%
Macular Pucker	0%	4.7%
Diplopia	0%	9.5%
Myopic chorioretinitis	0%	9.5%
PVD	0%	14.28%

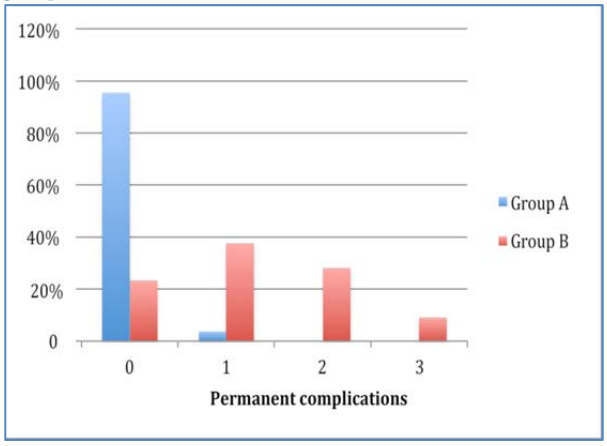
Table 3. Long-term postoperative complications (24 months post-operation). Retinal pigment epithelium (RPE); posterior vitreous detachment (PVD).

Permanent complications requiring medical/surgical treatment

The presence of permanent complications in the two groups of patients was also evaluated, defined as complications that did not go spontaneous resolution and required medical / surgical treatment for their healing (**Fig. 4**).

Only one case was found in Group A, while in Group B the distribution was more varied: 38.1% of the cases had a permanent complication, 28.6% of the cases had two, and 9.5% of the cases had three permanent complications. Again, the chi-square test showed high statistical significance (p-value <0.0001).

Figure 4. Permanent postoperative complications in the two groups.



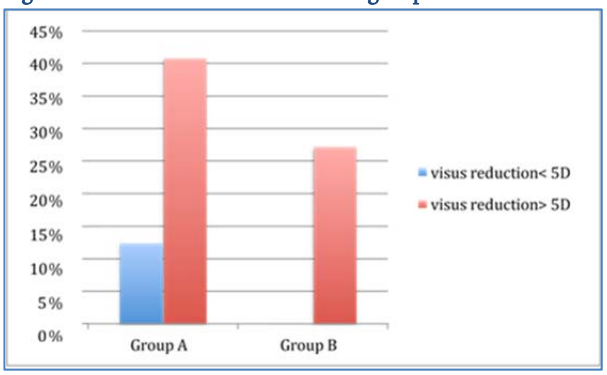
Evaluation of visus

Another aim of the study was the evaluation of changes in visus following the use of the two different surgical techniques. It was found that patients in group B most frequently exhibited a significant reduction in visus, due to the intrinsic modification of eye morphology induced by circumferential (**Fig. 5**). Taking into account the positive myopia history, it was shown that 40.9% of patients in Group B who completed the follow-up showed a mild to moderate reduction in visus (<5 D) (9 cases in 22 patients), while 27.3% showed a significant reduction in visus (> 5 D).

Patients of group A showed a slight reduction in visus in 12.5% of cases (3 cases out of 24 patients), whereas no major reductions in visus or astigmatism secondary to the intervention were reported. Following the observation that in the three cases of visus reduction, the retinal detachment also involved the macular region, we made a further evaluation: we investigated whether the subretinal fluid presence, which often persists in the first postoperative day after buckling, might affect visus due to impairment of retinal photoreceptors. Patients of the two groups where retinal detachment involved the macular region (macula: off) were selected (9 patients in group A, 8 patients in group B). To correlate the reduction of visus to macular involvement, patients in group B who had a visual acuity reduction of <5 D attributable to the axial change of the eyeball caused by circumferential were excluded.

Although the correlation was not statistically significant due to the reduced number of patients, it was found that, clinically, in these cases the drainage of the subretinal fluid does not affect the visus improvement. Reduction in visual acuity is probably only related to the actual macular detachment, and not at the time when retinal lifting is still ongoing.

Figure 5. Visus reduction in the two groups.



Discussion

This study was performed to evaluate the safety and efficacy of buckling surgery with respect to the circumferential+ buckling in rhegmatogenous retinal detachment therapy. Specifically, we recorded the intra and post-operative complications in a group of patients treated with circumferential and buckling techniques, compared to the control group, treated with buckling alone.

Our data showed that both techniques have proved to be effective in treating rhegmatogenous retinal detachment. This "ab externo" surgery was successful for the treatment of retinal detachment after first intervention in 96% of cases in Group A and 75% of patients in Group B.

Failure cases are due to a lack of visualization of a second retinal rupture in Group A, resulting in subretinal fluid retention, and the development of proliferative vitreoretinopathy (PVR) [25] Hwang et al., 2017) in the 7 cases belonging to the group B. The cause of PVR after treatment with circumferential + buckling is not yet known [5] (Kreissig, 2004), but it is probably related to excessive proliferation at a cicatricial site after cryopreservation [26] (Kwon et al., 2016). Nonetheless,

PVR would occur more rarely after treatment with just buckling (no case in our study), and this could suggest that another predisposing factor may be the excessive binding force of the circumferential [27] (Lindsell et al., 2016).

The safety of the two surgical techniques was evaluated in terms of intra and postoperative complications. The best manageability of the circumferential + buckling technique has avoided the development of intraoperative complications in Group B patients. However, the number and type of postoperative complications would indicate that the circumferential + buckling technique should not be adopted unless it is strictly necessary. The circumferential permits drainage that, although it allows the immediate retinal adhesion to the RPE, increases the risk of developing other complications, especially the endophthalmitis, although not reported in our study.

On the opposite, buckling requires a long learning period (low learning curve). In addition, without guaranteeing the complete bulb indentation of circumferential, it requires particular care in the search for undetectable retinal ruptures [28] (Tabandeh et al., 2000). In our study, we found that buckling, if properly performed by an experienced operator, is a safer surgical technique of circumferential + buckling.

The last point, fundamental to the patient, concerns the study of visual acuity in the two groups. In group A, patients with visual acuity reduction progressively improved visus during follow-up (12.5% of cases). In group B, a decrease in visus was found in most patients (72.7% of cases), with a reduction of more than five diopters in 31.8% of cases. Although visual acuity improved over time, in no case this improvement allowed the recovery of a natural visus> 6/10. Nonetheless, it should be mentioned that the best results were obtained in eyes of young patients, where functional adaptability allowed a visus correction even equal to 10/10.

Conclusions

Although rhegmatogenous retinal detachment represents an uncommon disease in the general population (1 case per 10,000 a year), it results in a serious reduction in the quality of life of the patient, with significant repercussions even on the simplest daily activities.

Both techniques, characterized by an "ab externo" approach of retinal detachment, allow treating the disease adequately in a non-invasive manner. Nonetheless, they exhibit statistically significant differences with regard to the postoperative course.

In light of the data obtained from the statistical analysis, we can state that both surgical techniques are effective in determining retinal adhesion to the RPE following rhegmatogenous retinal detachment. However, the use of buckling (minimal episcleral surgery) is safer and guarantees a better outcome on the patient visus, and is therefore preferable to the circumferential + buckling.

References

1. Michels RG, Wilkinson CP, Rice TA. Retinal Detachment. ST. Louis, CV Mosby Co, 1990; pp 459-505.
2. Hilton GF, McLean EB, Brinton DA. Retinal detachment: principles and practice, 2nd Edition. American Academy of Ophthalmology 1995; pp.120-128.
3. Mitri. D, Charteris D G, The epidemiology of rhegmatogenous retinal detachment: geographical variation and clinical associations. Br J Ophthalmol 2010;94:6 678-684.
4. Kanski JJ. Oftalmologia Clinica Sesta edizione 2007; pp.696-733.
5. Kreissig I. Primary retinal detachment: options for repair. Springer 2004; pp. 151-166.
6. Wolff B. Subretinal Surgery Ab Externo: A novel approach to access the subretinal space without the need for retinotomy. Retina. 2015 Jul;35(7):1474-5.
7. Kim YK, Yoon W, Ahn JK, Park SP. Scleral Buckling for Rhegmatogenous Retinal Detachment Associated with Pars Planitis. J Ophthalmol. 2016;2016:4538193.
8. Grizzard WS, Hilton GF, Hammer ME. A multivariate analysis of anatomic success of retinal detachment treated with scleral buckling. Greafes Arch Clin Exp Ophthalmol 1994; 232:1-7.
9. Banaee T, Hosseini SM, Ghooshkhanei H, Moosavi M, Khayyatzadeh-Kakhki S. Anatomical and visual outcomes of three different scleral buckling techniques. J Ophthalmic Vis Res. 2009 Apr;4(2):90-6.
10. Kreissig I. Minimization of detachment surgery. Klin Mbl Augenheilk 1989; 195:126-134.
11. Kreissig I, Rose D, Jost B. Minimized surgery for retinal detachment with segmental buckling and non drainage. An 11-year follow-up. Retina 1992; 12:224-231.
12. Pacella E, Pacella F, Troisi F, Dell'edera D, Tuchetti P, Lenzi T, Collini S. Efficacy and safety of 0.5% levobupivacaine versus 0.5% bupivacaine for peribulbar anesthesia. Clin Ophthalmol. 2013;7:927-32.
13. Takkar B, Azad S, Shashni A, Pujari A, Bhatia I, Azad R. Missed retinal breaks in rhegmatogenous retinal detachment. Int J Ophthalmol. 2016 Nov 18;9(11):1629-1633.
14. Schepens CL, Okamura ID, Brockhurst RJ. The scleral buckling procedures. 1. Surgical techniques and management. Arch Ophthalmol 1957: 58:797-811.

15. Arruga MH. Le cerclage equatorial pour traiter le decollement retinien. Bull Soc Franc Ophtal 1958; 71:571-580.
16. La Heij EC, Derhaag PF, Hendrikse F. Results of scleral buckling operations in primary rhegmatogenous retinal detachment. Documenta Ophthalmologica 2000; 100:17-25.
17. Tornambe PE, Hilton GF. Pneumatic retinopexy: the evolutio of case selection and surgical tecnique. A twelve year study of 302 eyes. Trans Am Ophthalmol Soc 1997; 95:551-578.
18. Malagola R, Pannarale L, Tortorella P, Arrico L. Drainage of subretinal fluid during scleral buckling surgery for rhegmatogenous retinal detachment. G Chir. 2015 May-Jun;36(3):106-11.
19. Pacella E, Collini S, Pacella F, Piraino DC, Santamaria V, De Blasi RA. Levobupivacaine vs. racemic bupivacaine in peribulbar anaesthesia: a randomized double blind study in ophthalmic surgery. Eur Rev Med Pharmacol Sci. 2010 Jun;14(6):539-44.
20. Sagong M, Chang W. Learning curve of the scleral buckling operation: lessons from the first 97 cases. Ophthalmologica. 2010;224(1):22-9
21. Hilton GF, Grizzard WS, Avins LR. The drainage of subretinal fluid: a randomized controlled clinical trial. Retina 1981;1(4)271- 280.
22. Heimann H, Bornfeld N, Friedrichs W. Primary vitrectomy without scleral buckling for rhegmatogenous retinal detachment. Graefes Arch Clin Exp Ophtalmol 1996; 234:561-568.
23. Richardson EC, Verma S, Green WT, Woon H. Primary vitrectomy for reghmatogenous retinal detachment: an analysis of failure. Eur J Ophthalmol 2000; 10:160-166.
24. Moshfeghi AA, Salam GA, Deramo VA. Management of macular holes that develop after retinal detachment repair. American Journal of Ophthalmology 2003; 136(5):895-899.
25. Hwang CS, Mendoza PR, Wells JR, Grossniklaus HE, Hubbard GB 3rd. Proliferative Vitreoretinopathy in Treated Retinoblastoma. Ophthalmol Retina. 2017 Mar-Apr;1(2):165-172.
26. Kwon OW, Song JH, Roh MI. Retinal Detachment and Proliferative Vitreoretinopathy. Dev Ophthalmol. 2016;55:154-62.
27. Lindsell LB, Sisk RA, Miller DM, Foster RE, Petersen MR, Riemann CD, Hutchins RK. Comparison of outcomes: scleral buckling and pars plana vitrectomy versus vitrectomy alone for primary repair of rhegmatogenous retinal detachment. Clin Ophthalmol. 2016 Dec 20;11:47-54.
28. Tabandeh H, Flaxel C, Sullivan PM, Leaver PK, Flynn HW Jr, Schiffman J. Scleral rupture during retinal detachment surgery: risk factors, management options, and outcomes. Ophthalmology. 2000 May;107(5):848-52.