International Journal of Physical Medicine & Rehabilitation

Vingolo EM et al., Int J Phys Med Rehabil 2014, S5:005
DOI: 10.4172/2329-9096.S5-005

Research Article | Open Access

Efficacy of Microperimetric Biofeedback after Retinal Detachment

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Received date: 01 Feb 2014; **Accepted date:** 24 April 2014; **Published date:** 26 April 2014

Abstract

Background: To evaluate visual recovery after rehabilitation with microperimetric biofeedback in patients submitted to surgery for retinal detachment.

Methods: We have randomly divided 44 eyes of 44 patients after surgery for retinal detachment into two group: group A, 23 eyes, submitted to biofeedback training with microperimetry MP-1, 10 training sessions, once a week, ten minutes for each eye; group B (control group), 21 eyes, treated with common care strategy. We have compared best correct visual acuity (BCVA) of two groups at baseline, 6, 12 and 18 weeks with Student's t test.

Results: At baseline the mean BCVA was 0.6 ± 0.43 logMAR in group A and 0.66 ± 0.67 logMAR in group B (p=0.74). At 6 weeks after training the mean BCVA of group A was 0.27 ± 0.29 logMAR significantly better (p=0.02) than group B (0.67 ± 0.67 logMAR). At 12 weeks the mean BCVA was 0.18 ± 0.25 logMAR in group A better than the control group in which the mean BCVA was 0.60 ± 0.66 logMAR (p=0.01). At 18 weeks visual performances were still better in biofeedback group than in group B (p=0.01) in which the mean BCVA was 0.58 ± 0.68 logMAR.

Conclusions: Microperimetric biofeedback allowed a better and faster visual recovery after surgery for retinal detachment than normal condition.

Keywords: Best correct visual acuity; Biofeedback; Microperimetry MP-1; Retinal detachment

Introduction

Successful reattachment of the macula after retinal detachment (RD) is often associated with incomplete visual recovery. Preoperative factors influencing macula recovery include preoperative visual acuity, duration and height of detachment, and vitreomacular traction. Postoperative clinical findings that are associated with incomplete recovery include cystoid macular edema, epiretinal membranes, retinal folds, retinal pigment epithelium (RPE) migration, and persistent subretinal fluid (SRF) [1]. Even with a normal-appearing macula on examination, patients often experience visual impairment.

In this study we have evaluated if it is possible to speed up recovery time in operated eyes by biofeedback rehabilitation with the MP-1 microperimeter (NIDEK Technologies Srl, Padova, Italy). Fundus-related microperimetry (MP) is a functional measure of macular sensitivity. The MP-1 Microperimeter measures several points in the patient's central field and effectively maps out microscotomas. An infrared camera establishes and tracks the patient's fixation, and the resulting visual field is registered onto the corresponding fundus photograph. In this manner, the functional defect can be localized to the anatomic macular abnormality. Studies have shown that the MP-1 results are reproducible and comparable to standard automated perimetry [2,3].

Visual rehabilitation is a therapeutic approach that has been applied to different ocular diseases characterized by visual deterioration and loss of stable central fixation [4].

The MP-1 Microperimeter biofeedback examination allows the ophthalmologist to train the patient to fixate the target with a new preferred retinal locus (PRL), which can be defined as a discrete retinal area that contains more than 20% of the fixation points. The term "preferred retinal locus" (PRL) describes a retinal area that acts as a pseudofovea for visual tasks when a central macular scotoma affects visual performance. Moreover, a sizeable proportion of patients use more than one.

PRL for a given task, It has been also found that some patients exhibit a re-referencing of the oculomotor system to the PRL, which leads them to say that they are looking straight ahead when they are fixating with the PRL (i.e. when the eye is not in the primary position). This phenomenon has been referred to as adaptive eccentric fixation or oculomotor re-referencing [5].

Methods

We enrolled 44 eyes of 44 patients (17 female and 27 male), who had come to the Department of Ophthalmology, "S.M. Goretti" Hospital. The mean age was 58,24 ± 14,05 years (range: 27-88 years old).

Exclusion criteria included

Eyes undergoing reoperation of primary failure or redetachment; eyes with a macular hole, age-related macular degeneration, or macular oedema; patients with advanced glaucoma, diabetic retinopathy.

Citation: Vingolo EM, Verboschi F, Domanico D, Fragiotta S, Spadea L (2014) Efficacy of Microperimetric Biofeedback after Retinal Detachment . Int J Phys Med Rehabil S5: 005. doi:10.4172/2329-9096.S5-005

The diagnosis of retinal detachment was based on a complete eye examination which included slit-lamp biomicroscopy, intraocular pressure test, best-corrected visual acuity (BCVA) test, and binocular indirect ophthalmoscopy.

Patients underwent surgery for RD between 2008 and early 2011.

Twenty-three eyes of twenty-three patients had scleral buckle surgery combined with cryopexy for macular-off RD by an individual surgeon (E.M.V.) Drainage of subretinal fluid was performed in all eyes. All operations were uncomplicated. Routine postoperative corticosteroids, antibiotics, and cycloplegics were prescribed and tapered over the subsequent postoperative weeks. All operations were uncomplicated. Routine postoperative corticosteroids, antibiotics, and cycloplegics were prescribed and tapered over the subsequent postoperative weeks. Twenty-one eyes of twenty-one patients were submitted to pars plana vitrectomy (PPV) with 23- gauge system associated with the internal filing with silicone oil (polydimethylsiloxane (PDMS) 1000).

After the surgery patients were randomly divided in two group: group A, that included 23 eyes, 12 buckled and 11 with PPV and PDMS tamponnade, was submitted to rehabilitation protocol with biofeedback (BF) MP-1; group B (control group), that included 21 eyes, 11 buckled and 10 with PPV and PDMS tamponnade, was treated only with common care. Retinal reattachment of the macula was tested with Optical Coherence Tomography (OCT) scans.

Institutional Review Board (IRB) approval was obtained; the possible merits and risks of the rehabilitation were explained to all patients and an informed consent was obtained in accordance with the Helsinki Declaration prior to inclusion in the study. Visual rehabilitation started 15 days after the suspension of cycloplegic eyedrops in buckling procedure or after silicone oil removal in PPV eyes.

Rehabilitation protocol consisted of

Microperimetry, 10 training sessions with MP-1 biofeedback.

Microperimetry and fixation test were performed with MP-1 microperimeter using the automated programme, the threshold test of 4–2 strategy, and a 1° single cross fixation target; however, at the beginning of the study the size was enlarged to a 2° single cross fixation target when patient was not able to see the 1° single cross fixation target. After training only 1° single cross target was used for all patients.

Retinal threshold sensitivity was measured in all eyes using the stimulus Goldmann III (round shape with a white background) with stimulus intensity ranging from 0 to 20 dB. Stimulus presentation time was 200 ms. After microperimetry it was chosen the new PRL. The rehabilitation protocol consisted of 10 training sessions of 10 minutes for each eye, performed once a week using the MP-1 acoustic target biofeedback examination. The patients were trained to fix the new PRL according to an audio feedback which advised them whether they were getting closer to the desired final fixation position. All the procedures were followed on a monitor. Best correct visual acuity (BCVA) of two groups was measured and it was compared at baseline, 6, 12 and 18 weeks after the start of the study.

BCVA was measured using a standard Snellen chart, and then converted to logarithm of the minimum angle of resolution (logMAR) for statistical analyses.

Statistical analysis was performed using Student's t-test and p values less than 0.05 were considered statistically significant.

Results

We have enrolled 44 patients (17 female and 27 male), mean patient age was 58.24 ± 14.05 years old (range: 27–88 years old), for a total of 44 eyes after surgery of retinal detachment. Patients underwent to surgery for RD between 2008 and early 2011. We have randomly divided patients in two group: group A, 23 eyes, with mean pre-operative BCVA of 1.48 logMAR, submitted to surgery after 2.3 days of diagnosis, was submitted to biofeedback training with microperimetry MP-1, 10 training sessions, once a week; group B (control group), 21 eyes, with mean pre-operative BCVA of 1 logMAR, submitted to surgery after 2.4 days of diagnosis, was treated with common care strategy only. All participants completed the study protocol.

At baseline the mean BCVA for both groups was: in A 0.6 ± 0.43 logMAR and in B 0.66 ± 0.67 logMAR with no statistically difference (p=0.75). At 6 weeks after training with microperimetric biofeedback the mean BCVA of group A was 0.27 ± 0.29 logMAR significantly better (p=0.02) than group B in which the mean BCVA was 0.67 ± 0.67 logMAR. At 12 weeks the mean BCVA was 0.18 ± 0.25 logMAR in group A better than the control group in which the mean BCVA was 0.60 ± 0.66 logMAR and this result was statistically significant (p=0.0109). At 18 weeks visual performances were still better in biofeedback group with the mean value of BCVA 0.15 ± 0.25 logMAR than in group B in which BCVA was 0.58 ± 0.68 logMAR and this result was statistically significant (p=0.01) (Figure 1).

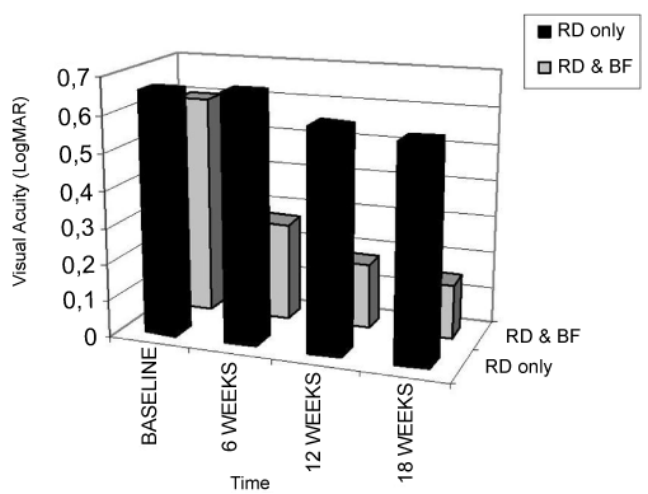

Figure 1: The graph shows BCVA of the group A who performed rehabilitation with MP-1 biofeedback (BF) and BCVA of the group B which was used as a control group at baseline, after 6 weeks, 12 weeks and 18 weeks.

Discussion

Scleral-buckling procedure is the most commonly used surgical treatment of rhegmatogenous retinal detachment (RD), with or without intravitreal gas injection [6]. After scleral-buckling procedure, visual recovery is related to the pre-operative and post-operative macular condition. A poor functional outcome is common because of post-operative complications, such as persistent subfoveal fluid, even in a pre-operatively uninvolved macula [7], epiretinal membranes, and cystoid macular oedema [1,8].

Pars plana vitrectomy (PPV) has become accepted as the treatment of choice for certain complex retinal detachments. The commonest indications are difficult breaks (for example, giant or macula) [9,10] or the presence of advanced proliferative vitreoretinopathy (PVR). In simpler rhegmatogenous retinal detachment (RRD) external buckling procedures are preferred generally [11,12].

Visual recovery after successful surgery for the macula-off rhegmatogenous retinal detachment continues to be an important topic for ophthalmologists. Salicone et al. studied the visual recovery after scleral buckling procedure for retinal detachment on 672 patients, including 457 (68%) with macular detachment. They showed that the use of gas, drainage of subretinal fluid, and lens status did not influence final anatomic or visual results. Visual recovery after retinal reattachment was most dependent on macular involvement. Duration of macular detachment had surprisingly little influence on postoperative visual acuity. Macular detachment was the most important prognostic factor for anatomic and visual acuity success [13]. Kusaka et al. have retrospectively investigated the long-term visual recovery in 32 macula-off retinal detachments that had been followed up for more than 5 years after surgery. They found that the best corrected visual acuities were better at 5 years than at 3 months by two lines or more in 17 eyes (53%). In these 17 eyes, visual acuity continued to improve for up to 10 years after surgery. The remaining 15 eyes demonstrated best corrected acuities that remained within one line of the 3-month values. The eyes that demonstrated long-term improvement in the postoperative period were found to be statistically correlated with younger age, no or mild myopia (less than -5.00 D), and shorter duration of macular detachment (30 days or less) [14].

In our study we have evaluated if it is possible to speed up recovery time in eyes after retinal detachment surgery with biofeedback rehabilitation with a MP-1 microperimeter (NIDEK Technologies Srl, Padova, Italy).

Biofeedback has been used for more than fifty years in rehabilitation to facilitate normal movement patterns after injury [15]. It is the technique of providing biological information to patients in real-time that would otherwise be unknown. Biofeedback usually involves measurement of a target biomedical variable and relaying it to the user using one of two strategies;

Direct feedback regarding the measured variable, as in the case of heart rate or heart rate variability, where a numerical value is displayed on a wearable device, such as a watch.

Transformed feedback regarding the measured variable, where the measurements are used to control an adaptive auditory signal, visual display or tactile feedback method [16].

At the end of rehabilitation protocol our data demonstrate that in group A the biofeedback training allowed a significant recovery in visual acuity after clinical healing of the retina that remains still evident after 18 weeks from the baseline. In fact the training with MP-1 Microperimeter biofeedback increases the BCVA after surgery for retinal detachment in a statistically significant compared to controls after 18 weeks of treatment because patients were trained to use the new PRL found by microperimetry.

Studies have demonstrated the efficacy of low-vision rehabilitation by means of MP-1 biofeedback examination in patients with different macular disease (vitelliform dystrophy, post-traumatic macular scar, Stargardt disease, myopic macular degeneration, cone dystrophy) and they demonstrated an improvement in visual acuity, fixation behaviour, retinal sensitivity and reading speed [4,17].

Crossland et al. showed that the MP-1 Microperimeter uses cerebral plasticity and neurosensorial adaptation to the central scotoma of patients with macular diseases to improve their visual abilities and more manageable visual aids. Indeed, such patients often develop a new PRL, which can be defined as a discrete retinal area that contains more than 20% of the fixation points [5].

PRL was chosen according to microperimetry as an area of higher sensitivity and fixation points also indicated by colours of interpolated map or by numbers of the numerical map. After placing the aim fixation on the PRL of patient, he are asked to move their eyes according to an audio feedback which tells them whether they are getting closer to PRL chosen by the ophthalmologist. Sound perception increases the conscious attention of the patient, thereby facilitating the lock-in of the visual target and increasing the permanence time of the fixation target itself on the retina. This mechanism facilitates stimuli transmission between intraretinal neurons as well as between the retina and brain, where the highest degree of stimuli processing takes place, thereby supporting a "remapping phenomenon" [18,19]. Improvement through biofeedback training in patients who suffer from macular disease which remain either stable or worsen, where the traditional treatment cannot offer further results, is of interest and well worthy of attention. The reasons of this improvement are due to the fact that we trained a "retinal motor" PRL, with appropriate retinal sensitivity, so as to increase the number of correct fixation saccades and re-reference the oculomotor system.

There could be improvement in ocular motor control and in 'searching capacity'. Furthermore, learning to use eccentric fixation could be a mechanism contributing to amelioration. Another suggestion is an increase in the discriminating capacities both of the retina and the visual cortex and associated areas. In particular it is very important to note that visual function could be improved because patients undergoing training improve their ability to demonstrate their best visual acuity and other visual abilities. When visual acuity in the better eye worsens in patients with binocular macular diseases, they sense an improvement of vision in the fellow eye. Since each cerebral hemisphere is stimulated by both monocular and binocular neurons, this improvement can be explained by the fact that activation in areas of residual vision, which are systematically stimulated with light, increases and patients are able to perceive visual stimuli in parts of the field that had previously been unresponsive or in which super threshold stimuli had not been detected as demonstrated by Poggel [20].

Another example of cerebral plasticity is blindsight, which was defined as a condition in which patients with damage in their primary visual cortex or its afferents retain the ability to detect, discriminate and locate visual stimuli presented in areas of the visual field in which they claim to be blind [21].

Cerebral plasticity is likely to play an important role. Neurons are thus able to respond to weaker stimuli than they responded to without attention. Alpeter demonstrated that attention also increases the coherence between neurons responding to the same stimulus [18].

The biofeedback effect is related to the brain's ability to perceive an efficient PRL for visual tasks. The audio feedback can, by increasing attentional modulation, help the brain fix the final PRL.

As found by Mezawa, auditory biofeedback can be useful for the treatment of patients affected by congenital nystagmus, that have reported a subjective gain and an improvement of foveation time, amplitude, and frequency at the end of the visual training [22]. In our previous study, we analyzed the structured training with biofeedback stimulus with microperimetry MP-1 (Nidek Technologies) efficacy in patients with age-related macular degeneration (AMD) in terminal stage. The study showed excellent results passing damaged photoreceptor layer and improving the integration process of outer segment and especially of the inner retina. The structural stimulus is addressed to the visual receptive fields highly sensitive to medium spatial frequencies, as this stimulus provides to the ganglion cells information much more effective than simple unstructured light stimulation as used in IBIS (improved biofeedback integrated system) device [23].

Techniques of biofeedback have been performed in the treatment of ametropia (myopia, astigmatism, presbyopia), nystagmus, amblyopia [24,25] and advanced glaucoma [26].

Andrade et al. have shown that patients are usually unaware of their scotoma because, when the retina is damaged by a local lesion (induced scotoma), the cortical neurons driven by stimuli originating in this region do not remain inactive but become selective to stimuli originating in other parts of the retina. This process occurs in two distinct steps, each with its own time scale: i) a fast redistribution of receptive fields (RFs) in the area of the lesion and ii) a long-term reorganization that leads to the final RF configuration. Although the mechanisms underlying the gradual rearrangement are becoming clearer, the first step remains obscure. Cortical neurons located in the retinotopic position corresponding to the scotoma receive some degree of activity from the unimpaired neurons in the area surrounding the lesion [27].

Cortical plasticity allows the brain to adapt to background modifications or to nervous system damage. It also underlies learning and attention processes. Cortical changes occurring after focal visual differentiation modify visual perception by filling in visual field defects with information from the area surrounding the scotoma. This modification causes affected subjects to ignore or underestimate their defects. With visual field defects, cortical plasticity also causes distortion in spatial perception. These effects cause delay the identification of visual field defects, and hence the initiation of therapy, while also affecting the results of some procedures to test the visual field [28].

Conclusion

Microperimetric biofeedback trains the neurotrasmission chain to increase intercellular neurotransmitters and to restore neuro-brain connections faster than in normal conditions.

References

1. Abouzeid H, Wolfensberger TJ (2006) Macular recovery after retinal detachment. Acta Ophthalmol Scand 84: 597-605.
2. Midena E, Radin PP, Convento E, Cavarzeran F (2007) Macular automatic fundus perimetry threshold versus standard perimetry threshold. Eur J Ophthalmol 17: 63-68.
3. Springer C, Bultmann S, Volcker HE, Rohrschneider K (2005) Fundus perimetry with the Micro Perimeter 1 in normal individuals: comparison with conventional threshold perimetry. Ophthalmology 112: 848-854.
4. Vingolo EM, Salvatore S, Cavarretta S (2009) Low-vision rehabilitation by means of MP-1 biofeedback examination in patients with different macular diseases: a pilot study. Appl Psychophysiol Biofeedback 34: 127-133.
5. Crossland MD, Culham LE, Kabanarou SA, Rubin GS (2005) Preferred retinal locus development in patients with macular disease. Ophthalmology 112: 1579-1585.
6. Ahmadieh H, Moradian S, Faghihi H, Parvaresh MM, Ghanbari H, et al. (2005) Anatomic and visual outcomes of scleral buckling versus primary vitrectomy in pseudophakic and aphakic retinal detachment: six-month follow-up results of single operation. Report no. 1. Ophthalmology 112: 1421-1429.
7. Theodossiadis PG, Georgalas IG, Emfietzoglou J, Kyriaki TE, Pantelia E, et al. (2003) Optical coherence tomography findings in the macula after treatment of rhegmatogenous retinal detachments with spared macula preoperatively. Retina 23: 69-75.
8. Rossetti A, Doro D (2002) Retained intravitreal lens fragments after phacoemulsification: complications and visual outcome in vitrectomized and non vitrectomized eyes. J Cat Refr Surg 28: 310-315.
9. Billington BM, Leaver PK (1986) Vitrectomy and fluid/silicone oil exchange for giant retinal tears. Results at 18 months. Graefes Arch Clin Exp Ophthalmol 224: 7-10.
10. Gonvers M, Machemer R (1982) A new approach to treating retinal detachment with macular holes. AmJ Ophthalmol 94: 468-472.
11. Lean JS, Leaver PK, Cooling RJ, McLeod D (1982) Management of complex retinal detachments by vitrectomy and fluid/silicone oil exchange. Trans Ophthalmol Soc UK 102: 203-205.
12. Sternberg P, Machemer R (1985) Results of conventional vitreous surgery for proliferative vitreoretinopathy. AmJ Ophthalmol 100: 141-146.
13. Salicone A, Smiddy WE, Venkatraman A, Feuer W (2006) Visual recovery after scleral buckling procedure for retinal detachment. Ophthalmology 113: 1734-1742.
14. Kusaka S, Toshino A, Ohashi Y, Sakaue E (1998) Long-term visual recovery after scleral buckling for macula-off retinal detachments. Jpn J Ophthalmol 42: 218-222.
15. Tate JJ, Milner CE (2010) Real-time kinematic, temporospatial, and kinetic biofeedback during gait retraining in patients: a systematic review. Phys Ther 10: 1123-1134.
16. Giggins OM, Persson UM, Caulfield B (2013) Biofeedback in rehabilitation. J Neuroeng Rehabil 10: 60.
17. Pacella E, Pacella F, Mazzeo F, Turchetti P, Carlesimo SC, et al. (2012) Effectiveness of vision rehabilitation treatment through MP-1 microperimeter in patients with visual loss due to macular disease. Clin Ter 163: 423-428.
18. Altpeter E, Mackben M, Trauzettel-Klosinski S (2000) The importance of sustained attention for patients with maculopthies. Vision Research 40: 1539-1547.
19. Buia C, Tiesinga P (2006) Attentional modulation of firing rate and synchrony in a model cortical network. Journal of Computational Neuroscience 20: 247–264.
20. Poggel DA, Mueller I, Kasten E, Sabel BA (2008) Multifactorial predictors and outcome variables of vision restoration training in patients with post-geniculate visual field loss. Restor Neurol Neurosci 26: 321-339.
21. Sahraie A, Hibbard PB, Trevethan CT, Ritchie KL, Weiskrantz L (2010) Consciousness of the first order in blindsight. Proc Natl Acad Sci U S A 107: 21217-21222.
22. Mezawa M, Ishikawa S, Ukai K (1990) Changes in waveform of congenital nystagmus associated with biofeedback treatment. Br J Ophthalmol 74: 472-476.

23. Vingolo EM, Cavarretta S, Domanico D, Parisi F, Malagola R (2007) Microperimetric biofeedback in AMD patients. Appl Psychophysiol Biofeedback 32: 185-189.

24. Trachtman JN (1978) Biofeedback of accomodation to reduce myopia. A case report. Am J Optom Physiol Opt 55: 400-406.

25. Leung V, Wick B, Bedell HE (1996) Multifaceted treatment of congenital nystagmus: a report of 6 cases. Optom Vision Sci: 73: 114-124.

26. Verboschi F, Domanico D, Nebbioso M, Corradetti G, Zaccaria Scalinci S, Vingolo EM (2013) New trends in visual rehabilitation with MP-1 microperimeter biofeedback: optic neural dysfunction. Funct Neurol 28: 285-291.

27. Andrade MA, Muro EM, Moran F (2001) Simulation of plasticity in the adult visual cortex Biol Cybern 84: 445-451.

28. Safran AB, Landis T (1996) Plasticity in the adult visual cortex: implications for the diagnosis of visual field defects and visual rehabilitation. Current Opinion in Ophthalmology 7: 53-64.

This article was originally published in a special issue, entitled: **"Surgical Rehabilitation",** Edited by J Luo, Temple University School of Medicine, USA