

MYSTERIES REGARDING THE SURGICALLY REATTACHED RETINA

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ABSTRACT

Purpose: To present contemporary information regarding the continued inability to reliably predict visual acuity following successful retinal reattachment surgery.

Methods: Literature review.

Results: Anatomical results of surgery for retinal detachment continue to be far superior to visual results. Clinical factors that have been considered important in predicting postoperative visual acuity include preoperative vision, duration of detachment, height of detachment, and preoperative potential acuity meter results. Recently, optical coherence tomography (OCT) studies have been employed for the purpose of predicting postoperative visual acuity, but to date none of these devices can precisely forecast postoperative vision in an individual eye.

Conclusions: Preoperative visual acuities appear to be the most important clinical variants correlating with postoperative visual results. Although advanced OCT techniques have identified preoperative and postoperative anatomical alterations that correlate with preoperative and postoperative visions in groups of eyes, no single specific finding indicates unequivocal visual success, and most reports continue to include examples of exceptions to statistical trends.

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INTRODUCTION

Rhegmatogenous retinal detachments (RRDs) were virtually irreparable until the classic work of Jules Gonin,¹ who proved the cause of the disorder by creating a method of anatomical repair. Anatomical results from Lausanne and elsewhere rather quickly reached approximately 50% of operated cases, and this figure has continued to improve over the past 80 years. Nevertheless, there are very few data that indicate significant improvement in visual results, barring complications, and it appears that postoperative vision is usually predetermined by the status of macular function at the time of surgery.²

Clinical variables that have been considered important in predicting postoperative visual acuity following repair of macula-off retinal detachments include duration and/or height of macular detachment, preoperative vision measured routinely or with a type of potential visual acuity meter, age of the patient, and additional macular pathology. Nonclinical variables employed for the same purpose include laboratory measurements such as multifocal electroretinograms (ERGs), contrast sensitivities, and, more recently, optical coherence tomography (OCT).

The purpose of this report is to review the literature in an attempt to discover if an optimal method of predicting postoperative visual acuity following successful retinal reattachment surgery exists or if major inconsistencies in the apparent values of the variety of “predictors” remain a reality.

METHODS AND MATERIALS

A thorough literature review of MEDLINE was conducted to discover all apparent articles in the English language that discussed results of surgery for RRD, visual acuity outcomes, and potential preoperative predictors of postoperative vision. These were subdivided into “clinical variables” and “laboratory values,” and manuscripts that were considered to contain the most reliable data are discussed in this study.

Internal review board approval and care of animals were considered to be irrelevant.

RESULTS

Clinical variables were discussed more commonly in older articles, whereas newer manuscripts have emphasized discussions of laboratory predictors, particularly OCT.

CLINICAL VARIABLES

Clinical variables included duration and height of retinal detachment, preoperative visual acuities measured routinely or with a variety of additional devices, and additional macular pathology.

DURATION OF MACULAR DETACHMENT

The length of time that a macula is detached due to a RRD has long been considered important in predicting recovery of vision following successful surgery. However, the importance of the specific duration of macular detachment has been debated for decades. Many individuals have stated that every hour of detachment may be critical, whereas others have concluded that once a macula has detached, there is little difference in visual outcomes if the detachment is repaired within 7 days,³ 10 days, 14 days, or even longer. Virtually all of these studies are flawed, with an essential element being the reality of the effect of preoperative vision and/or

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additional variables. Clearly, better visual acuity would be expected following repair of a shallow macular detachment of 2 months duration due to a retinal dialysis and with 20/40 visual acuity than would be predicted following cure of a detachment of 3 days duration and a visual acuity of hand motions.

HEIGHT OF MACULAR DETACHMENT

The amount of elevation of the detached macula has been considered as a critical variable in predicting postoperative visual acuity, particularly in cases of macular detachment of less than a week.⁴ However, extreme variations are observed; for instance, in one report,⁴ 3 cases had macular detachments of 0.6, 2.0, and 4.9 mm in height and preoperative visual acuities of 20/400, hand movements, and counting fingers, respectively, and all were detached for 2 days. Postoperatively, visual acuities were 20/20, 20/20, and 20/40, respectively. However, a fourth case had a macular detachment of 1 day's duration and a height of 0.7 mm. Preoperative vision of hand movements did not improve beyond this level.

PREOPERATIVE VISUAL ACUITY

Doyle and coworkers⁵ are among a large number of individuals who state that preoperative visual acuity is the most important clinical variable predicting recovery of postoperative vision. Although duration of detachment was also considered to be important, in a multivariate analysis preoperative vision was the only strongly predictive factor. Friberg and Eller⁶ reported a similar relationship when preoperative vision was measured with a potential acuity meter. Still, there are occasional uncomplicated cases in which relatively good preoperative vision does not improve following successful surgery.

LABORATORY VARIABLES

A variety of laboratory studies, including OCT, have been employed in an effort to discover preoperative predictors of postoperative visual success.

NON-OCT LABORATORY STUDIES

Ozgun and Esgin⁷ correlated duration of macular detachment with preoperative and postoperative visual acuity, visual evoked potential, color vision, contrast sensitivity, and visual fields. Although all of these indicators of macular function demonstrated trends to improve following successful surgery, there was significant scatter of the data. In another report,⁸ multifocal foveal ERG amplitudes were reduced preoperatively and returned to normal following surgery in spite of demonstrating no correlation with postoperative visual acuity.

OCT STUDIES

OCT devices have become invaluable in the assessment of macular disorders, and it has been hoped that they might provide insights into macular damage associated with RRD as well as causes of relatively poor postoperative vision. Residual subretinal fluid following clinical reattachment is much more common than previously suspected. In addition, undulations, intraretinal separations, intraretinal cysts, distortion of inner and outer photoreceptor segments, and other changes have been described. The newer high-speed spectral-domain, Fourier-domain, and custom OCT devices have greatly improved the resolution of these studies, and greater attention has been directed toward attenuation, alteration, and disruption of the junction line between photoreceptor inner and outer photoreceptor segments in particular. However, the correlation of these findings with postoperative vision remains inconsistent.

Residual Subretinal Fluid. In a prospective study, Cavallini and coworkers⁹ described residual subretinal fluid in two-thirds of cases 1 month following successful reattachment surgery. At the sixth postoperative month, subretinal fluid remained in a third of eyes, and poor visual acuity was associated with this finding. However, Seo and associates¹⁰ discovered no relationship between residual subretinal fluid and ultimate visual acuity, even though the former was present postoperatively in 52% at 1 month, 25% at 6 months, 17% at 9 months, and 0% at 12 months.

Intraretinal OCT Changes. A consistent difference between macular detachment due to RRD and to central serous chorioretinopathy (CSR) has been the presence of several OCT changes in only the former group, and it well recognized that both prerelation and postrelation visual acuities are traditionally lower in the former group. Still, a precise correlation between OCT changes and visual acuity is lacking.

Lee and coworkers¹¹ matched 15 eyes with RRD and 15 with CSR and demonstrated no apparent structural changes in the latter group. However, in the RRD cases, preoperative retinal cysts were observed in 10, intraretinal separations in 9, and undulation of the outer retina in 6. In 4 cases all 3 of these findings were present; in 5 eyes 2 of the 3 changes were observed. Three cases had one change, and the remaining 3 had none. Postoperatively, 2 eyes exhibited intraretinal cysts, but no changes were observed in the remaining 13. There was a trend for preoperative and postoperative vision to be better in the cases with relatively few preoperative intraretinal changes, but some eyes with 2 or more changes had better postoperative visions than cases with only one or none.

Nakanishi and coworkers¹² demonstrated similar findings with spectral-domain OCT but also discovered photoreceptor disruption in 40% of RRD cases. Postoperative vision correlated with preoperative vision, height of detachment, and photoreceptor disruption. However, 2 eyes with the latter preoperative changes achieved 20/25 and 20/20 postoperative visual acuity.

Retinal thickness and outer nuclear layer thickness were studied with high-speed OCT in a selected series of cases with RRD and CSR by Maruko and coworkers.¹³ The thickness of the outer nuclear layer was greater in the RRD group than the CSR group, but significant differences in retinal thickness were not observed. Although postoperative vision was stated to correlate significantly with outer nuclear layer thickness, there were several exceptions to this statistical premise.

Another recent study¹⁴ evaluated the maculas postoperatively in both macula-on and macula-off RRDs with Fourier-domain OCT. Foveal anatomical abnormalities were discovered in 62% of cases. Disruption of the photoreceptor inner segment/outer segment (IS/OS) junction line (61%) and the external limiting membrane (24%) was observed only in macula-off cases, whereas additional changes were noted in both types of detachments. This disruption was statistically related to relatively poor postoperative visual acuity. The investigators also noted in following some of the cases with a disrupted inner/outer photoreceptor line with or without disrupted external limiting membrane that restoration of a normal IS/OS line occurred only in eyes without an initially disrupted external limiting membrane. Eyes in which the IS/OS junction returned to normal exhibited better visual acuity than those in which this change did not occur. It should be noted that visual acuities in the 38% of cases without OCT abnormalities were not discussed in this report.

DISCUSSION

Visual acuity success continues to be less satisfactory than the anatomical outcomes of surgery for retinal detachment. The basic cause is clearly macular damage associated with the presence of subretinal fluid, although complications of surgery can be compounding factors.

A variety of clinical variables have been studied over the past decades in an effort to predict postoperative vision, but there are exceptions to virtually all correlations that have been studied to date, and it is difficult to avoid a conclusion that the health of the macula at the time of reattachment is the most critical variable, barring surgical complications. More recently, laboratory investigations have studied the function and anatomy of postoperative cases, and in particular high-speed OCT studies have demonstrated a variety of previously unrecognized interesting changes associated with diminished vision. Still, the reason that some eyes with similar alterations fare significantly better than others remains a genuine mystery. This is an active area of basic retinal research, and the attempt to limit the amount and severity of photoreceptor cell death will hopefully become increasingly fruitful in future years.

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PEER DISCUSSION

DR. TIMOTHY W. OLSEN: Dr. C. P. Wilkinson is to be congratulated on providing both the historic perspective as well as a thorough review of the most recent advances in imaging technology used to investigate the ever perplexing clinical challenge of

offering the patient a visual prognosis in the setting of a rhegmatogenous retinal detachment (RRD). Dr. Wilkinson points out the fact that while anatomic results have improved dramatically over the past 80 years, visual acuity outcomes trend toward the anatomic reattachment success, but lag in reaching the potential goals of functional success, namely excellent, post-operative central visual acuity.

The topic of variables in the clinical setting of retinal detachment warrants a brief review of *common cause variation* versus *special cause variation*. Common cause variation is a source of variation caused by unknown factors that result in a steady but random distribution of the data around the mean, so called noise in the system. Special cause variation is caused by known factors that result in non-random distribution of output. These cases usually represent the outliers in a system, and are a signal of a specific variable that falls outside of the normal variation. An example of special cause variation in this clinical setting would be the development of a large submacular hemorrhage that may rarely occur during external drainage performed during reattachment surgery that results in a poor visual acuity outcome.

Based on our current knowledge of both clinical and laboratory variables in predicting final visual acuity in macula-off retinal detachments, it is clear that there is a significant amount of noise or variability at predicting final visual acuity. The figures presented by Dr. Wilkinson highlight the data distribution. While not specifically stated, Dr. Wilkinson is very careful to point out that we should avoid a type I statistical error, namely that of recognizing the rather broad range of common cause variation in our tests. Moreover, he is also careful to avoid type II statistical error. Specifically, Dr. Wilkinson is careful to point out that preoperative visual acuity represents the most important clinical variable and OCT findings are the most important laboratory variable, thus avoiding the excessive skepticism that would result from failure to recognize that these differences represent real separation from common cause variation. While additional statistical meta-analysis of the literature may help to address individual variables, the results would not likely lead to a different conclusion.

What other questions arise to help understand the variables that are involved in this clinical setting. Let's take the case of a macula on retinal detachment, where the superior retina is bullous and overhangs the fovea. The anatomic fovea may be attached, yet the central visual acuity may be significantly impaired, thus giving us a falsely poor visual acuity prediction. What about pre-operative visual function testing in general? Do we take the time to refract patients to the level of the macula off detachment? Is this even possible when the fluid under the fovea is shifting or fluctuating? How much effort will the patient make during an acuity test or even a potential acuity test, if he/she is worried about a severe, vision-threatening event that is about to require urgent surgical intervention? A careful refraction may seem irrelevant. Likewise, can the pattern stimulus image of a mfERG be properly focused on the macula pre-operatively in order to adequately assess its functional status? There are also numerous surgical variables. How complete was the drainage? Was there some hemorrhage into the subretinal space during drainage? How healthy is the retinal pigment epithelium that is required to pump subretinal fluid away from the subretinal space? Was there any postoperative inflammation, an epiretinal membrane, or choroidal congestion from encirclement? Finally, were there systemic factors involved such as diabetes or hypertension?

In summary, Dr. Wilkinson has shared his wealth of experience in the evaluation of patients with rhegmatogenous retinal detachments, and has provided us an knowledgeable, objective and rational review of the literature in order to provide the best predictors of final visual acuity in our patients with rhegmatogenous retinal detachments. The relative importance of variation in this setting is well addressed. Finally, I echo his enthusiasm regarding newer imaging technologies such as SD-OCT that enable better analysis of detailed macular anatomy and presumably macular function.

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DR. JERRY SEBAG: No conflicts. I agree with Pat Wilkinson and Dr. Olsen in that everything we have studied so far does not answer the question. I propose that what we need to evaluate the biochemical aspects. I have studied subretinal fluid in patients with retinal detachments and assayed S-antigen levels. The results presented in *Investigative Ophthalmology and Visual Science* in 1997 correlated with the clinical experience that visual acuity will not improve after two weeks of detachment because the S-antigen levels increased over the two week period. We also in a subsequent study measured neuron specific enolase (NSE) as an indicator of neuronal stress in subretinal fluid, aqueous humor, and blood. We published in *Current Eye Research* in 2001 that there are also elevated levels of NSE in the blood associated with retinal detachment. I proposed therefore that biochemical markers may shed more light on the mechanism than structural evaluations, such as OCT. Lastly, we should conceive of a reattachment as a corollary of CNS stroke. Ischemia is not as damaging to the CNS as is reperfusion injury. When we reposition the detached retina on to the RPE choroid complex that has already broken down, possible hyperoxia and the free radical damage could indeed induce cellular damage that could limit postoperative vision. Perhaps we need to look at just how gently we reattach the retina in search of better visual acuity.

DR. DAVID J. WILSON: No conflicts. We tend to focus on the photoreceptors as the limiting factor on visual acuity, but there is considerable evidence that it is actually the processing within the retina that is the limiting factor. One of the early changes that Steve Fisher showed in some of the studies you referred to are changes in the inner retina. Current OCT technology does not detect this very well, but perhaps there will be some correlate that can be made of that in the future that will predict visual acuity outcome.

DR. PAUL E. TORNAMBE: I enjoyed the review of CP, as usual. It is very enlightening and raises many questions. I believe that follow-up time is really important. As you pointed out, delayed absorption of subretinal fluid can sometimes take a year, and many published papers do not have one year follow-up. Of course, if you are doing a buckle or vitrectomy you also must deal with cataracts. In the pneumatic trial, we compared the six month follow-up data with the two-year data. Visual acuity was considerably better after two years in both in the buckling and pneumatic groups, so it is important to know the visual acuity at the two year point. I also suggest you compare the visual acuity results with the surgical procedure. As you know, I believe that the best vision is obtained when the detachment is treated with pneumatic retinopexy. I think that big fat buckles affect the circulation to the eye, and can result in chronic macular edema. Even when I do a buckle, a rarely externally drain subretinal fluid and rely on the RPE pump. I continue to believe that the less one does to reattach the retina, the better the visual acuity outcome.

DR. C. P. WILKINSON: Thank you. There is not much to comment upon except to review a couple of points that have been made. When the macula detaches, a cascade of events follows, including molecular and cellular events that lead to damage. Jerry Sebag mentioned biochemical markers. These may prove to be important. It is also true that this concept of overheating or too much oxygen too quickly may be playing a role. This why there is some excitement over neuroprotection and an attempt to eliminate some of these reparative cascades. David Wilson mentioned some processing in the retina, and I believe that the precise location of the cellular events are probably multiple and not exclusive. Paul, thank you for your comments. Obviously if you carry out postoperative vision evaluations after two years, then you can continue to see some improvement. Your point is very well taken. Thank you.