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# Motility and binocularity outcomes in vitrectomy versus scleral buckling in retinal detachment surgery

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**Abstract** ● Background: Ocular motility defects and loss of binocularity are well-recognised problems following retinal detachment surgery. It is presumed that scleral buckling is primarily responsible for these effects. The increasing use of vitrectomy in the management of retinal detachment might be expected to reduce the incidence of these defects.
● Method: Two groups of patients presenting with primary uncomplicated rhegmatogenous retinal detachments were examined following a single surgical repair. The first group underwent vitrectomy (*n*=17), the second group, scleral buckling / external surgical techniques (*n*=23).
● Results: Heterotropia was present in 24% (*n*=4) of the vitrectomy group and 30% (*n*=7) of the "external" group, with suppression reported clinically in 8 of these and diplopia by the other 3. While ocular movements were frequently full (vitrectomy 59%, external 61%), restricted vertical movements were observed in 35% of the vitrectomy group and 26% of the external group, with horizontal and general restrictions being rare (6% and 13% respectively). True motor fusion was more common for the external group (44%) than the vitrectomies (24%), while superimposition was more frequent in the vitrectomies (64%; external 39%). The latter was achieved only with correcting prisms in 18% of vitrectomies and 9% of the external group. The remainder did not demonstrate any potential for binocularity. Visual symptoms were more frequent among the vitrectomy group, with aniseikonia and torsion significantly more common. ● Conclusions: The findings confirm that ocular motility problems are not exclusive to scleral buckling, with the incidence being similar in both groups. Slinging of the extraocular muscles and the accompanying dissection, resulting in the 'fat adherence syndrome', must be considered as contributory factors. The visual deficits which inevitably occur as the result of retinal detachment seem to play a more major role in the disruption of binocularity in these cases.

## Introduction

Diplopia and extra-ocular muscle restriction following conventional external retinal detachment surgery is well documented. Strabismus and diplopia have been reported in up to 72% of cases in the short-term [9, 13], the incidence reducing to 5–25% in the long-term [10, 11]. Extra-ocular muscle restrictions are reported in up to 65% of cases [13, 16]. Higher rates of muscle restrictions are associated with secondary and multiple procedures and encircling bands [9, 10]. The reduction in incidence over time is considered to be primarily attributable to phoria adaptation, a mechanism which is disrupted in cases of initial poor post-operative visual acuity (VA) [9].

The mechanisms postulated for strabismus and ocular motility restrictions are varied and numerous including:

direct interference (resulting in change in vector forces) or injury to the muscle caused by scleral buckling; rupture of the muscle belly by excessive traction on the stabilising suture; scarring resulting in fibrosis and adhesions secondary to disruption of Tenon's capsule; misplaced muscle and sensory disruption of fusion as a result of the visual disturbance [11, 18, 20].

The closed microsurgical technique of vitrectomy is now extensively utilised as a primary procedure for rhegmatogenous retinal detachment repair [2, 4, 6, 14, 19], but virtually nothing is reported about its influence on ocular motility, with one study to date reporting no cases of diplopia following vitrectomy [3] and another postulating that motility disorders should not occur with vitrectomy [8]. In theory, the removal of any external factors which may interfere directly with the ocular muscles should significantly reduce or eliminate the risk of ocular muscle restrictions [7, 18]. This theory is tested in the current study in a group with primary rhegmatogenous retinal detachment by comparing two groups who underwent initial retinal surgery: one group primary vitrectomy, the other group the more conventional external scleral buckling. This was not a randomised study since the surgery carried out reflected the individual case requirements according to the surgeon, policy at this time being to perform a primary vitrectomy procedure in the repair of the retinal detachment where it was amenable to closure with internal tamponade alone.

## Materials and methods

The study was undertaken over a 12-month period from April 1997 to March 1998 in the vitreo-retinal clinic of the Glasgow Eye Infirmary. All patients were overseen by two consultant vitreo-retinal surgeons (T.B. and H.M.H.). Only patients who had undergone primary rhegmatogenous retinal detachment repair were included, and those with no previous history of strabismus or amblyopia, nor any systemic disease which may have influenced ocular motility. It is therefore assumed that these patients had normal retinal correspondence prior to the detachment. Forty patients met this criterion: 18 males and 22 females, with an age range of 17–93 years (mean 53±20 years). Seventeen had undergone primary vitrectomy and the other 23 primary external scleral buckling.

At the time of this study it was the policy of the retinal surgeons involved (T.B. and H.M.H.) to perform primary vitrectomy as the procedure in the repair of a retinal detachment where the causative pathology was above the horizontal meridian. A standard three-port pars plana vitrectomy was carried out with internal drainage of subretinal fluid, followed by fluid/gas exchange in 15 cases and oil in 2 cases, to effect internal tamponade. External cryotherapy or endolaser photocoagulation was applied to secure adhesions in the region of the retinal tear, which was often at the site of muscle insertion, particularly the obliques. All cases had muscle slings, usually the two horizontal recti muscles, to facilitate movement of the eye. Buckling consisted either of post-oral encircling bands where appropriate ($n$=9), with solid Silastic explants circumferentially or radial sponges. None of the vitrectomy group had any additional external buckling elements.

The pre-operative macular status assigned by the ophthalmologist was "off" in 19 cases and "on" in the other 21 cases. The time between surgery and post-operative orthoptic assessment was within 3 months in 25 cases, 3 to <6 months in 5 cases and 6 months or over in the other 10 cases.

All patients had Snellen visual acuity recorded and were assessed by one of two senior orthoptists (L.A.W. or M.C.) to determine binocular outcomes and ocular motility status following retinal detachment repair. Orthoptic investigation comprised: cover test, ocular movements, assessment of sensory and motor fusion, and convergence. Grading of ocular motility status was by diagrammatic representation [15]. This employs a 9-point scoring system from –4 to +4, with minus indicating an underaction and plus an overaction. Assessment of binocularity proved difficult by conventional means due to the visual impairment in some cases. A Bagolini lorgnette was adapted with red filters and testing was carried out at a distance of 1 m, which facilitated easier perception of the striations in those with poor VA. This is a test of sensory fusion, and used in conjunction with prisms allows the motor status to be determined. We previously validated this method in a group of subjects without retinal detachment, half of whom had a significant myopic refractive error akin to the retinal detachment group. No significant difference was found in the subjects ability to perceive a "cross" indicating sensory fusion, or in the motor fusion range (base-out or base-in) when assessed with or without the additional red filters ($p$>0.1 assessed by Chi-square test), but it did facilitate recognition of the striations.

In addition to recording any reported subjective symptoms, a detailed questionnaire of additional symptoms was administered. These comprised: diplopia, distortion/torsion (metamorphopsia), aniseikonia and interocular colour differences.

## Results

Results are reported in relation to post-operative ocular motility findings, presence of a heterotropia, binocular status and subjective symptoms. These are considered in relation to the type of retinal surgery undergone, pre-operative macular status and post-operative VA. Two arbitrary VA levels of ≥6/12 (consistent with driving standard) and ≥6/36 (deemed consistent with a reasonable level of independent mobility) were applied for the purpose of statistical analysis.

### Motility

Ocular motility restrictions were evident in similar proportions of the operated eye of both groups (Table 1), with vertical motility being most commonly affected ($n$=12), and elevation more frequently ($n$=10) than depression ($n$ = 2), with only one patient from each group demonstrating restricted depression. The latter was not considered to be due to senile restriction of elevation since it was monocular. The degree of restriction was only mild (–1) for both horizontal cases, but the degree of vertical and general restriction was greatest in those who had undergone external surgery (–3 or –4) compared with the vitrectomy group (all –2) (Table 1).

### Heterotropia

Heterotropia was present in the primary position in 24% ($n$=4) of the vitrectomy group and 30% ($n$=7) of the scleral

**Table 1** Ocular motility in relation to retinal procedure ($n$=40). The degrees of restriction were not significantly different for the two groups (Wilcoxon signed rank test Z–1.6, $P$=0.11)

| Surgical procedure | Full | Restricted vertical movement | Restricted horizontal movement | Restricted in all directions |
|---|---|---|---|---|
| Vitrectomy ($n$=17) | 10 (59%) | 6 (35%) | 1 (6%) | 0 |
| Motility grading | | 6 (–2) | 1 (–1) | |
| External ($n$=23) | 14 (61%) | 6 (26%) | 1 (4%) | 2 (9%) |
| Motility grading | | 5 (–3); 1 (–4) | 1 (–1) | 2 (–4) |

**Table 2** Binocular vision outcome in relation to retinal procedure ($n$=40). There was no significant difference between the groups in the proportion that demonstrated motor fusion / superimposition (Chi-square 0.24, $P$=0.62)

| Surgical procedure | Binocular status | | | |
|---|---|---|---|---|
| | Superimposition | Motor fusion | No fusion / suppression | No fusion / diplopia |
| Vitrectomy ($n$=17) | 11 (64%)* | 4 (24%) | 2 (12%) | 0 |
| External ($n$=23) | 9 (39%)* | 10 (44%) | 1 (4%) | 3 (13%) |

* Two patients of the vitrectomy group and three of the external group had potential superimposition, which was achieved with correction of their deviations with prisms

buckle group. All of these demonstrated a degree of vertical deviation, but in four cases the deviation was purely vertical (three scleral buckle, one vitrectomy) and in the other seven a horizontal component was evident. The direction of horizontal deviation was divergent in four cases (two from each group) and convergent in the other three cases (two scleral buckle, one vitrectomy). In addition, many of those who maintained binocular single vision (BSV) in the primary position displayed a small vertical phoria.

## Binocularity

True motor fusion with a range of vergences was demonstrated in more of the scleral buckle group (44%) than the vitrectomy group (24%). Conversely, the weaker binocular functions of superimposition or sensory fusion were evident in a greater proportion of the vitrectomy than the scleral buckle group (Table 2). Three of the scleral buckle group and two of the vitrectomy group achieved superimposition of images only when their deviation was corrected by prisms (the response indicated in Table 2), but reported diplopia ($n$=3) or suppression ($n$=2) at their uncorrected angle. Thirteen per cent of those who had undergone scleral buckling reported diplopia on clinical examination with the Bagolini lorgnette, but none of the vitrectomy group. The binocular status was considered further in relation to VA (Fig. 1) and macular status (Fig. 2) to determine whether there was any relationship between these factors.

As expected, better post-operative VA (≥6/36) in the detached eye was associated with a better binocular outcome, with more of those with higher VA demonstrating both sensory and motor fusion. In fact, none of those with poor VA (≤6/60) displayed a motor fusion range. Good

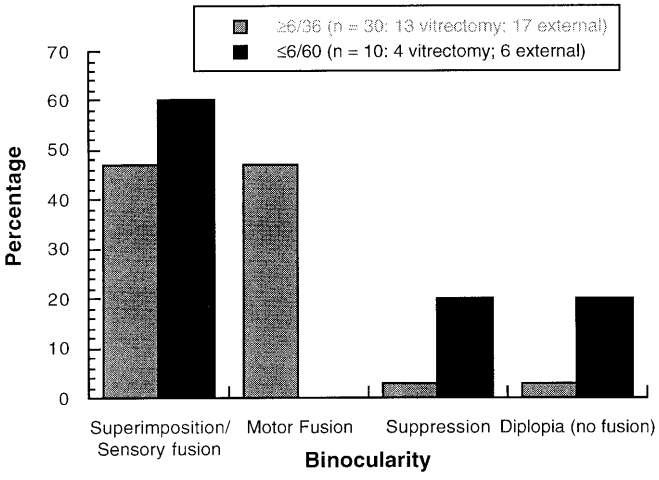


**Fig. 1** Binocularity in relation to visual acuity

VA did not ensure binocularity, with a small proportion demonstrating diplopia or suppression. Neither did poor VA protect against the appreciation of binocular diplopia.

Similarly, a higher proportion of those with macula "on" demonstrated sensory and motor fusion than those with macula "off", and conversely a higher proportion of those with macula "off' had diplopia or suppression. The initial macular status clearly did influence the final outcome, but the binocularity results were not always predictable by this means.

On reviewing VA outcome in relation to macular status, macula "off" was more commonly associated with a poorer visual acuity outcome (37% ≤6/60) than macula "on" (14% ≤6/60). However macula "off" pre-operatively did not exclude a good visual acuity outcome, with

**Table 3** Final subjective symptoms in relation to retinal procedure. A subject could have more than one symptom recorded; significance levels were calculated only for those symptoms with a difference of 10% or more ($\chi^2$ Chi-square test)

| | Symptom | | | | | | |
|---|---|---|---|---|---|---|---|
| Surgical procedure | None | Diplopia | Distortion | Aniseikonia | Torsion | Colour | Other |
| Vitrectomy ($n$=17) | 3 (18%) | 3 (18%) | 3 (18%) | 9 (53%) | 7 (41%) | 6 (35%) | 6 (35%) |
| External ($n$=23) | 8 (35%) | 4 (17%) | 6 (26%) | 5 (22%) | 0 (0%) | 3 (13%) | 7 (30%) |
| | $\chi^2$ 1.4, $P$=0.23 | | | $\chi^2$ 4.2, $P$=0.04 | $\chi^2$ 11.5, $P$=0.003 | $\chi^2$ 2.8, $P$=0.1 | |

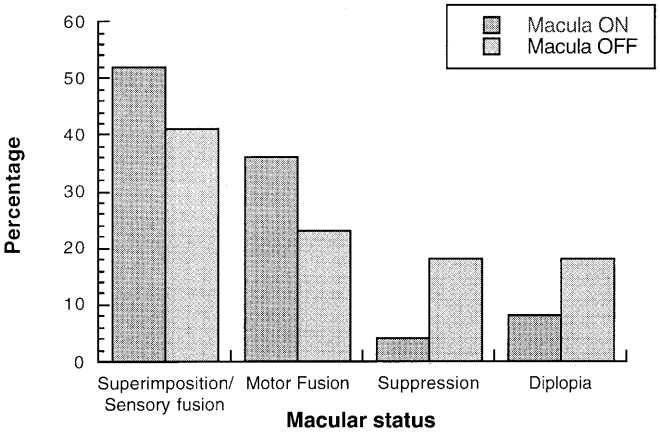


**Fig. 2** Binocularity in relation to macular status

16% of those thus presenting achieving 6/12 or better, compared with 24% of those with macula "on".

### Final subjective symptoms

The most predominant post-operative symptoms among the vitrectomy group were aniseikonia, torsion and distortion, occurring in over half of this group (Table 3). Aniseikonia and torsion were significantly more common in the vitrectomy group ($P \leq 0.05$). It is interesting to note that only two of this vitrectomy study group had silicone oil, both of whom reported aniseikonia. This raises the question as to the mechanism of aniseikonia in the other vitrectomy patients. These symptoms featured to a much lesser extent in the scleral buckle group, being reported in approximately a quarter of the patients. Diplopia was reported in almost equal proportions of the two groups (17% of the vitrectomy group and 18% of the scleral buckle group). Only 18% of the vitrectomy group were asymptomatic compared with 35% of the scleral buckle group.

## Discussion

The predominance of restricted vertical movement in this study, and in particular elevation, may be explained by the positioning of the tractional sutures or muscle slings prior to retinal surgery, which may reflect the high incidence of retinal detachments reported affecting superior retina [6], although this was not specifically looked at in this group. The common finding of a small vertical deviation in the primary position is most likely to be attributable to the associated vertical muscle restriction. Misalignment of retinal receptors on macular reattachment may also account for a small vertical deviation [12]. While the horizontal deviations may be due to underlying suture sites, they are more likely to be secondary to sensory disruption, and the almost equal proportions of esotropes and exotropes may reflect the unknown pre-operative heterophoria.

BSV with motor fusion was lost in the majority of both groups, but in a greater proportion of the vitrectomy group. The reasons for this can only be postulated, as there are many potentially interactive factors. VA and macular status were undoubtedly influential, with a better outcome associated with the retention of macular function in the macula "on" group and reasonable VA. Normal BSV and high-grade stereopsis require bifoveal fixation and a high level of VA. The reduced acuity and loss of bifoveal fixation in many of the study group prevented the appreciation of stereopsis. Certainly in the cases with macular detachment, bifoveal BSV is no longer possible, and only peripheral fusion mechanisms can act to maintain BSV. Aniseikonia is also a recognised factor in the disruption of binocularity [11], and we would speculate that the greater incidence of this and visual distortion experienced by the vitrectomy group resulted in a lower proportion of this group having a measurable fusion range. Post-operative refractive error was not considered in this group since VA tested with a pinhole did not improve significantly. The introduction of corneal astigmatism following the scleral incisions in pars plana vitrectomy has been reported [17], and may affect binocularity via the sensory input which is implicated by the final subjective symptoms reported in Table 3. Possible mechanisms of aniseikonia are a change in refractive error associated with the use of oil or compression of the globe by external factors. The absence of diplopia at the time of BSV assessment may also be explained by this mechanism, with the symptoms of anisei-

konia and metamorphopsia being more prominent than that of diplopia. It may be that in the small number of cases in whom moderate acuity was associated with diplopia or suppression, the quality of vision was not conducive to BSV. Since 16% of those with macula "off" pre-operatively achieved 6/12 or better acuity, one can assume that surgery must have been successful in re-attaching the macula. This process is, however, unlikely to have re-established the pre-detachment status, and misalignment of retinal receptors post-operatively is almost certain. The normal spatial sense accorded the retinal receptors, which underpins normal retino-cortical correspondence, is therefore likely to have been disturbed, thus preventing sensorial fusion [1].

Although a large proportion of the subject group reported symptoms, it is recognised that these were deliberately asked about, and these may not have been particularly troublesome. It is of interest that a larger number of the vitrectomy group reported symptoms of aniseikonia and metamorphopsia, which has been related to the use of intra-ocular silicone oil [5]. On retrospective review of this factor, however, only two patients from the vitrectomy group in this sample with symptoms of aniseikonia and metamorphopsia had silicone oil tamponade.

It is clear from this study that the use of vitrectomy surgery for rhegmatogenous retinal detachment does not eliminate the risk of ocular motility restrictions and subsequent diplopia. This finding supports primary violation of Tenon's capsule and the fat adherence syndrome as the principal aetiology of restricted motility as a complication of retinal detachment surgery [20], as well as disruption of sensory fusion as a consequence of visual distortion. Further elucidation of the sensory disruption in apparently recent-onset and rapidly repaired detachment is required to fully understand the process.

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