Spatial Localization after Different Types of Retinal Detachment Surgery

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PURPOSE. To compare the effect on spatial localization of two different forms of surgery for primary rhegmatogenous retinal detachment.

METHODS. Two groups of 30 patients (one group undergoing conventional external scleral-buckling procedures, the other undergoing vitrectomy procedures) were recruited. They pointed at targets appearing on a computer touchscreen without being able to see their hands, while viewing targets with the non-surgically treated eye. The sizes of the horizontal pointing errors were recorded on three separate occasions: before surgery, on the first postoperative day, and approximately 10 days later.

RESULTS. On the first postoperative day a significant change in localization of 2.9 ± 0.9° (SD) was observed in the scleral-buckling group, compared with 1.3 ± 0.6° in the vitrectomy group. These changes resolved by the second postoperative assessment.

CONCLUSIONS. These results, particularly in patients in the scleral-buckling group in whom greater manipulation of the extraocular muscles inevitably occurs, are consistent with an alteration in the extraretinal eye position information that is used in spatial localization. This is likely to be a consequence of modified efference copy and/or extraocular muscle proprioception. (Invest Ophthalmol Vis Sci. 2001;42:1495–1498)

The ability to locate the position of objects in the surrounding visual world (spatial localization) is an important aspect of normal visual function. For this to occur with precision the brain must know the direction in which a person is looking, and it depends to a large extent on visual (i.e., retinal) input for this information. However, because the eyes are able to move within the orbits, retinal information by itself is not adequate to specify this visual direction. Further nonvisual (i.e., extraretinal) information regarding the position of the eyes is required to interpret the retinal data and thus determine the direction of gaze. It is believed that this extraretinal eye position information is obtained from two distinct extraretinal sources: monitoring of the motor command sent to the extraocular muscles (efference copy or corollary discharge) and extraocular muscle proprioception. However, the relative contribution of each has been an issue of great controversy for many years.

The task of pointing at targets in surrounding space is an established method for assessing spatial localization, particularly if subjects are unable to see the pointing hand. Integration of the retinal and extraretinal information from the sources outlined in the prior paragraph enables the location of the object of interest to be determined with accuracy. To reach out, or point to this object, an appropriate motor command is sent to the arm and hand, which allows the efficient performance of the task. Patients who undergo conventional scleral-buckling surgery for retinal detachment have been shown to make errors when asked to perform such tasks of spatial localization, while viewing targets with the surgically treated eye. These changes are attributed to alterations in extraocular muscle proprioception, as a consequence of the perioperative manipulation of the muscles.

However, the visual information available to these patients in the immediate postoperative period (i.e., acuity and field of vision) must also have altered. This is likely to contribute to these errors than the change in proprioception. A more interesting finding is the postoperative localization shifts found in 4 of 10 of these patients when they were tested while viewing targets with the surgically treated eye. This is reasonable to assume that under these circumstances, modified extraocular muscle proprioception from the surgical eye influences the central interpretation of gaze direction, particularly because it is known that eye position information from both eyes is used for this very purpose. If this were the case, then patients who undergo retinal detachment surgery that does not directly involve manipulating the extraocular muscles (i.e., vitrectomy) would not be expected to demonstrate any localization changes after surgery when viewing with the fellow nonsurgical eye. To test this hypothesis a comparison of the effect on spatial localization of two different surgical procedures for primary rhegmatogenous retinal detachment—conventional external scleral-buckling surgery and vitrectomy—was made.

METHODS

All procedures conformed to the Declaration of Helsinki for research involving human subjects. Ethics committee approval was obtained, and informed consent was given in all cases. This was a comparative nonrandomized prospective study that was undertaken during a 6-month period from April to October 2000, within the Vitreo-retinal Service at the Tennent Institute of Ophthalmology, Gartnavel General Hospital, Glasgow, Scotland, United Kingdom.

Protocol

The testing protocol was very similar to that described in a previous study. Subjects were seated and viewed a computer touchscreen (luminance 57 candela [cd/m²]; IBM, Greenock, UK) from a distance of 40 cm. Their heads were stabilized with chin rests and cheek pads. Pictures of three vertical poles were presented on the screen: in the center and 15° to the left and to the right of center (Fig. 1). A red target
‘Ball’ which moves onto successive targets (poles)

(a ball, 1.5 cm in diameter, luminance 45 cd/m²) appears on the top of one pole, and the subject is asked to touch the screen at the bottom of the pole on which the ball has landed, with the outstretched index finger of the dominant hand. The ball then moves randomly to the top of another pole, and the subject is asked to touch the location of this pole.

No limit of time was placed on the pointing response. The target was presented on 10 separate occasions to each pole, and the location of each pointing response was stored online for later analysis. The disparity between the true location and the mean touched location of the 10 presentations was taken as the horizontal pointing error for that pole. A trial run was allowed in which the subjects could initially visualize the pointing hand to enable them to become familiar with the testing procedure. A cardboard sheet covered with black cloth was then used to mask the lower part of the screen, thereby preventing the pointing hand’s being seen. The subjects were allowed to practice with this in place before the formal testing session began. Each subject was tested before surgery (either the day before or the day of surgery) and again on the first postoperative day. A further test was performed on the first follow-up clinic visit, approximately 10 days later. All four of the rectus muscles were slung to aid movement of the eye. The vitrectomy procedures consisted of a standard three-port pars plana approach, with internal drainage of subretinal fluid, followed by fluid–gas exchange. External cryotherapy was applied in the region of the retinal hole(s). No muscle slings or external buckles were used in the vitrectomy group.

Table 1. Clinical Details of the Two Groups of Patients

<table>
<thead>
<tr>
<th></th>
<th>Scleral Buckling</th>
<th>Vitrectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>48 ± 17</td>
<td>55 ± 15</td>
</tr>
<tr>
<td>Refractive error (D)</td>
<td></td>
<td></td>
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<tr>
<td>Surgical eye</td>
<td>−3.40 ± 3.6</td>
<td>−3.30 ± 4.4</td>
</tr>
<tr>
<td>Fellow eye</td>
<td>−3.30 ± 3.5</td>
<td>−3.10 ± 4.2</td>
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<tr>
<td>Affered eye (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Left</td>
<td>16</td>
<td>13</td>
</tr>
</tbody>
</table>

Age and refractive error are expressed as means ± SD. Refractive errors represent mean spherical equivalent in diopters.
Spatial Localization after Retinal Detachment Surgery

This study demonstrates that spatial localization in patients with primary rhegmatogenous retinal detachment alters significantly more after external scleral-buckling procedures compared with vitrectomy procedures, when viewing with the nonsurgical eye. The technique we used is a recognized method for assessing localization.7–11 Although a randomized nonsurgical eye. The technique we used is a recognized method for assessing localization.7–11 Although a randomized

![Figure 2](http://iovs.arvojournals.org/pdfaccess.ashx?url=/data/journals/iovs/933588/) Comparison of changes in localization between the preoperative and first postoperative testing sessions (filled bars) and between the preoperative and second postoperative testing sessions (open bars) for both patient groups. Error bars, SD.

this, the data were collapsed to obtain a single value of the mean pointing response for each patient for that particular testing session. In the scleral-buckling group there was a significant shift in spatial localization of 2.9 ± 0.9° (SD; 95% confidence interval 2.4–3.2°) on the first postoperative day (Fig. 2). This was statistically significant (P < 0.0001, t = 17.9; one-sample t-test). In the vitrectomy group there was also a significant shift in spatial localization of 1.3 ± 0.6°; 95% confidence interval 1.1–1.5°) on the first postoperative day (P < 0.0001, t = 12.5; Fig. 2). A comparison of the changes in localization observed in each of these two groups at this time showed that they were significantly different from each other (P < 0.0001, t = 8.55; unpaired t-test). At the subsequent follow-up assessment 10 days later, these changes had returned toward preoperative values in both groups of patients (Fig. 2). For example, there was a small, nonsignificant difference between the preoperative and second postoperative testing sessions of 0.5 ± 0.7° (P = 0.25, t = 1.2) in the scleral-buckling group and 0.4 ± 0.6° (P = 0.35, t = 0.95) in the vitrectomy group. There was no significant difference between the changes observed in each group (P = 0.14, t = 1.4). No correlation was found between the age or refractive errors of the patients and the size of localization shifts.

**Discussion**

This study demonstrates that spatial localization in patients with primary rhegmatogenous retinal detachment alters significantly more after external scleral-buckling procedures compared with vitrectomy procedures, when viewing with the nonsurgical eye. The technique we used is a recognized method for assessing localization.7–11 Although a randomized study would have been optimal, it was not feasible, because the decision about the type of surgery to be performed was determined by the clinical status of each patient.

The results from the scleral-buckling group are consistent with those previously reported by Campos et al.,12 not only in the size of the localization shifts, but also in the time taken for the observed changes to return to their preoperative values, approximately 10 days later. However, they noted alterations in only 4 of 10 patients when testing the fellow non–surgically treated eye. In contrast, we noted changes in all subjects who underwent scleral-buckling surgery, ranging from 1.5° to 4.6°. It is possible that this difference is related to the more sensitive technique we used, in which pointing responses were recorded on a computer touchscreen, rather than the method Campos et al.12 describe, in which the position of the target was indicated on a piece of paper. The pointing changes we found in this group are of a similar magnitude to those in previous studies in which extraocular muscle proprioception was manipulated experimentally, resulting in mean localization shifts of 2.516 and 2.9817. They are also in keeping with the findings of Steinbach and Smith8 who observed changes after strabismus surgery, results that were attributed to modified afferent feedback from the extraocular muscles of the surgically treated eye.

To the best of our knowledge alterations in spatial localization after vitrectomy procedures for retinal detachments have not been reported previously. Why should these changes occur after a procedure that does not appear to involve the extraocular muscles directly? As was discussed in the introduction the viewer relies on a combination of both retinal (visual) and extraretinal information to determine the location of targets with respect to himself or herself. Because all the patients were tested with the surgical eye patched, and because the visual acuity of the nonsurgical eye remained the same after surgery, then an alteration in retinal information is unlikely to account for the results. This indicates that a nonvisual (i.e., extraretinal) signal has influenced spatial localization in the fellow eye. As was outlined earlier, there are two possible sources of this extraretinal information: efference copy and extraocular muscle proprioception.

Could the efferent copy of the oculomotor command change after vitrectomy? This is possible, particularly because ocular motility problems have been reported after this procedure.18 However, it should be noted that these changes were recorded several months after surgery, and little is known about ocular motility in the immediate postoperative period. In addition, our testing was performed monocularly, when viewing with the normal fellow eye, and according to Walls,19 the visual system monitors only the efference command sent to the dominant eye. Bridgeman4 also supports the concept that there is only one copy of the efferent command. Because there is no reason to believe that the motility of the nonsurgical eye has changed, we cannot be sure whether efference copy influenced the extraretinal eye position signal under the circumstances of our testing procedure.

The other possible source of the modified extraretinal information is extraocular muscle proprioception. Although no muscle slings or scleral buckles were used during the vitrectomy procedures, a degree of manipulation and rotation of the globe during surgery is inevitable. This may have produced swelling and inflammation in the periorbital tissues in proximity to the extraocular muscles, which in turn could have caused an alteration in proprioceptive feedback. It is also conceivable that periorbital, rather than extraocular, muscle receptors may be the source of this modified afferent signal.20 However, there is little direct evidence to support the existence of such receptors, as used in this study.

Although we cannot discount the role of efference copy after vitrectomy, the balance of evidence suggests that the changes in spatial localization we observed are related to an alteration in a nonvisual feedback signal derived from the surgical eye. The most likely source of such a signal is extraocular muscle sensory receptors.

Although the prime concern in patients who undergo any form of retinal detachment surgery is successful reattachment of the retina with improved visual function, in our experience some patients report difficulty in judging the position of objects relative to themselves. Although this is likely to be related to reduced acuity in the affected eye, combined with postoperative inflammation and mydriasis, our findings suggest that particularly after scleral-buckling procedures, modified ex-
traocular muscle proprioception could be a contributory factor immediately after surgery. What effect these and other surgical procedures involving the extraocular muscles, have on other aspects of visual function, such as oculomotor control, is not known, but perhaps warrants further assessment.

References