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EFFECT OF UPPER AND LOWER LIDS ON TRANSLATION OF RIGID BIFOCAL LENSES

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Segmented or alternating vision bifocal contact lenses require lens translation. This vertical movement can be obtained mainly by a combination of movements of the globe and resulting lid positions.

The initial accepted theory involved the lower lid pushing the contact lens upward upon downward gaze (reading position) thus placing the nearpoint portion of the lens in the line of sight. The latest theory was proposed by Irvin M. Borish, O.D., in 1985.[1]

Borish investigated and concluded that the lower lid theory, which essentially assumes no change in lower lid position with downward gaze, is erroneous. Borish concluded, based on a number of photographs with a variety of lenses with bifocal designs, except in cases of very high lower lid positioning on the cornea, that contact lenses are appropriately positioned in the reading position more often by upper lid grasp of the lens than by interposition of the lower lid margin against the bottom of the lens.

In this study, I have investigated vertical movement of two types of rigid contact lenses upon downward gaze: prism ballasted and minus carrier lenticular lenses, in order to prove or disprove that vertical translation of a contact lens is produced via upper lid action. Theoretically, the prism ballasted lens should, in effect, be moved by the lower lid upon which it rests and the minus carrier lenticular would be grasped and moved about by the upper lid.

Methods

Using a black and white video camera, lens movements were filmed with the eyes in the primary position as well as declined in the reading position. A special mount for the video camera was constructed placed at 15.5 degrees which is considered the average angle that the line of sight forms when repositioning from primary to reading position gaze.

A metric ruler was filmed to facilitate the conversion of screen measurements to actual measurements. The subjects' eyes were then filmed, without a contact lens, in the primary and reading position gazes to allow for corneal diameter measurements. After the keratometric readings were obtained for the right eye, minus carrier lenticular lens was fitted 'on K' and filmed in both primary and reading position gazes. The prism ballasted lens was marked with a Sanford Co. Vis a Vis permanent ink fine point felt pen and fitted 'on K' and filmed in primary and reading position gazes.

An anesthetic was placed in the eye prior to insertion of each lens to prevent hypersecretion of tears which in turn would have caused unnatural lens movements.

The distance of the upper margin of the lower lid was measured relative to selected anatomical landmarks on the eye in the primary and reading position gazes. The distance from the bottom of the minus carrier lenticular lens was measured relative to the anatomical landmarks in the primary and reading position gazes. The distance from the ink blot on the inferior portion of the prism ballasted lens was measured relative to the anatomical landmarks in the primary and reading position gazes.

Results

It was observed that there is a potential upward movement of 0.91mm of a contact lens due to lower lid positioning upon gaze into the reading position. This mean value was obtained by measuring the distance between anatomical landmarks on the globe and the upper margin of the lower lid of ten eyes (table 2, column 1) in the primary and reading positon gazes. The difference in the gap created by the two different gazes accounts for the potential upward movement.

Measurement of the distance between the bottom of the minus carrier lenticular and the anatomical landmarks of ten eyes in the primary and reading position gazes revealed a mean value of 0.52mm. This value represents the upward movement of the lens upon downward gaze. It was also found with subject number eight (table 1) that the lens did not position under the upper lid. In spite of this fact the lens translated upward 0.4mm.

A mean value of 0.9mm was obtained when the distance was measured between the anatomical landmarks and the ink blot on the inferior portion of the prism ballasted lens on ten eyes. This value represents the upward movement of the lens upon downward gaze. Subject number eight (table 2, column 3) had an unusually large gap between the upper margin of the lower lid and the inferior limbus. This gap probably accounts for the 2.5mm value obtained for the prism ballasted lenses' upward movement upon downward gaze.

Discussion

In previous studies it was observed, via still photography, that the lower lid moves downward 4mm[1] when the eye is depressed into the

reading position. The extent to which the line of sight is lowered to read at near is obtained by the common clinical experience used to determine the position of the top of a spectacle bifocal before the eyes. Most bifocal spectacle lenses are fitted with the top of the bifocal coincident vertically with the upper margin of the lower lid. Placed at this height, with the spectacles at a vertex distance of 13mm in front of the eyes, the top of the spectacle segment will be about 5.25mm below the distance optical center of the spectacle lenses. The exact height would vary somewhat depending on the lower lid/inferior limbus relationship.

The optical center of the usual D-25 straight top spectacle bifocal is placed 5mm below the upper edge of the segment. This would make the total distance from the optical center of the pupil, to the optical center of the segment about 10.25mm. Assuming that the center of rotation of the eye is 12.5mm behind the cornea, the rotation of the line of sight from the distance optical center of the lens to the near optical center of the segment lowers the center of the pupil approximately 5mm.

Based on the two observations above: 4mm of downward movement of the lower lid and 5mm of downward movement of the line of sight, Borish was able to conclude that the abutment of the bottom of the lens against the lower lid margin can only raise the segment a maximum of 1mm into the pupil.

The data in this paper agrees with the above conclusion. The gap based on an average, was found to be 0.91mm less between the lower lid and the anatomical landmarks chosen upon downward gaze. Hence, there is the potential upward movement of a lens resting on the lower lid with downward gaze of approximately 1mm.

The average upward movement of the minus carrier lenticular via the upper lid was found to be 0.5mm and the average upward movement of the prism ballasted lens was found to be 0.9mm. If subject number eight is omitted from the calculation of the mean, because of the abnormal anatomical lid/limbus relationship, the new average values become 0.53mm and 0.70mm for the minus carrier lenticular and the prism ballasted lenses respectively. The 0.17mm difference between the two values is clinically small. Therefore, the amount of vertical translation induced by the grasp of the minus carrier lenticular lens by the upper lid is essentially the same as the vertical translation induced by the lower lid upon the prism ballasted lens.

The implications of the conclusions made above, concerning lower lid versus upper lid positioning of bifocal contact lenses, would suggest that for the average patient neither form of fitting would be advantageous over the other. It may be feasable for the prescribing clinician to use either method: minus carrier lenticular or prism ballasted lenses to achieve equal amounts of upward positioning of an alternating or segmented bifocal contact lens. If a patients' lower lid is a considerable distance below the inferior limbus then, the clinician could conceivably fit a minus carrier lenticular lens positioned under the upper lid. In the opposite situation, in which the upper lid is positioned well above the superior limbus, the bifocal contact lens could be made in prism ballasted form to abut the lower lid.

The observations made in this paper, stating that there is no advantage of the upper lid over the lower lid for proper lens translation can be utilized when considering a patient for the prescription of bifocal contact lenses.

There were some difficulties encountered in collecting the data for this study.

When working with the video camera it was sometimes necessary to refocus the camera after moving from patient to patient or from primary to secondary gaze positions. The refocusing process can lead to magnification differences between the two gazes. As it turned out the magnification differences encountered were negligible. It would have been more efficient to have recorded a scale in each measurement taken to avoid magnification differences. Also, a color video camera would have allowed anatomical landmarks to be viewed easier and therefore improve accuracy of measurements.

The contact lenses utilized in this study were fitted 'on K' based solely on the Keratometric readings. To insure that each lens was indeed fitted 'on K' it probably would have been beneficial to check fluorescein patterns.

The actual movement of the upper lid is another aspect of this study which could have been pursued in more detail. The downward movement of the upper lid upon downward gaze would either have helped to support or disprove the conclusions made in this paper. This will be measured from the existing videotape and incorporated into the paper prior to publication.

TABLE 1

Subject #	Distance Gaze (Lower lid)	Near Gaze (Lower lid)	Distance Gaze (Minus carrier)	Near Gaze (Minus carrier)	Distance Gaze (Prism)	Near Gaze (Prism)
1	5.2mm	4.6	4.7	4.2	3.2	2.5
2	6.4mm	5.1	3.7	3.6	5.1	4.3
3	6.4mm	5.6	3.1	2.5	3.6	3.2
4	8.0mm	7.1	5.2	4.8	5.1	4.6
5	6.6mm	6.0	3.1	2.7	3.9	3.0
6	7.5mm	6.6	3.9	3.7	3.7	2.8
7	5.2mm	4.5	5.3	4.1	5.8	4.3
8	5.7mm	4.6	3.6	3.2	5.8	3.3
9	5.4mm	3.7	4.2	3.4	4.5	4.4
10	3.6mm	3.1	3.7	3.1	2.1	1.7

Key: Each column represents a distance from specifically chosen anatomical landmarks to: LL (lower lid), MCL (minus carrier lenticular lens), PB (prism ballasted lens) in 1° (primary gaze) and 2° (secondary or reading position gaze).

TABLE 2

Subject #	Upward Movement Of Lower Lid Upon Downward Gaze	Upward Movement Of MCL Upon Downward Gaze	Upward Movement OF PB Lens Upon Downward Gaze
1	0.6mm	0.5mm	0.7mm
2	1.3	0.1	0.8
3	0.8	0.6	0.4
4	0.9	0.4	0.5
5	0.6	0.4	0.9
6	0.9	0.2	0.9
7	0.7	1.2	1.5
8	1.1	0.4	2.5
9	1.7	0.8	0.1
10	0.5	0.6	0.4
	9.1	5.2	9.0

Mean Values

0.91mm	0.52mm	0.90mm

Mean Values Omitting Subject #8

0.88mm	0.53mm	0.70mm

TABLE 3

CONTACT LENSES USED

	Minus Carrier Lenticular	Prism Ballast
BCR	7.0 - 8.3mm	7.0 - 8.3mm
SCR	8.0 - 9.3mm	8.0 - 9.3mm
DIA	9.5mm	9.5mm
OZD	7.5	7.5mm
FOZD	7.7	
CT	0.185	0.185
ET	0.20	
JT	0.13	
CARRIER R	8.6 - 10.6	
POWER	+3.00 D	+3.00 D
POLYMER	PMMA	PMMA 1.5 p.d.

REFERENCES

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2. Mandell, R.B.: Contact Lens Practice, 3rd ed., Charles Thomas, Illinois, pp. 715, 1981.