1990

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A Comparison Study of Three Rigid Gas Permeable Lens Designs in the Fit of Low Plus Lenses

ABSTRACT: This article describes a comparison study of movement and centration of +3.00D rigid gas permeable lenses. Three lens designs were used; regular carrier lenticulars, minus carrier lenticulars and single cut lenses. Choice of lens design is an important aspect in fitting gas permeable lenses. This article attempts to show how lens design of plus lenses makes a difference and what those differences are. Statistically the lenticular designs show better centration and less movement than the single cut design.

KEY WORDS: gas permeable lenses, regular carrier lenticulars, minus carrier lenticulars, single cut lenses

Gas permeable lenses come in two basic designs; single cut and lenticular[1]. The front surface of a single cut lens is one continuous curve, whereas a lenticular lens design consists of a front optical portion surrounded by a peripheral carrier. The lenticular design helps reduce the center thickness of a plus lens. Indications for single cut lens design include; narrow vertical palpebral aperture, tight upper lid tension, lower lid margin at or above limbus, with-the-rule corneal toricity, keratometry readings of >45.00D, dyscoria(oval), and inferiorly displaced pupil[2]. In contrast, indications for lenticular lens design include; large palpebral aperture, loose upper lid tension, lower lid margin below limbus, against-the-rule corneal toricity, keratometry readings <45.00D, and superiorly displaced pupil[3]. In general, single cut lenses have been used to correct small refractive errors and lenticulars large refractive errors because of their improved centration from decreased center thickness[4]. Aphakic lenses are available in both lenticular and single cut design, however, the lenticular design is usually preferred because of its decreased center thickness. Thicker lenses are heavier and tend to ride low.

Designing a lens that it is held up by the upper lid will provide greater comfort for the patient than an interpalpebral lens[5]. When given a choice, a patient will generally

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1 Barr JT. Hard contact lens fitting guidelines. In: Barr JT, ed. Contact Lens Pocket Guide, 1st Ed., Allergan Optical, 1987: 35-64.

2 Grohe RM. Aphakia. In: Bennett ES, Groche RM Rigid Gas-Permeable Contact Lenses, Fairchild, New York, 1986: 411-429.

3 Grohe RM. Aphakia. In: Bennett ES, Groche RM Rigid Gas-Permeable Contact Lenses, Fairchild, New York, 1986: 411-429.

4 Barr JT. Hard contact lens fitting guidelines, In: Barr JT, ed. Contact Lens Pocket Guide, 1st Ed., Allergan Optical, 1987: 35-64.

5 Lowther GE . Review of Rigid Contact Lens Design and Effects of Design on Lens Fit, Big Rapids, Ferris State University, College of Optometry: 1-13.

choose a larger diameter for increased comfort[1]. Larger diameter lenses are often preferred because they provide better centration and adherence[2]. The center thickness is increased with a larger diameter lens, therefore for a similar diameter and power a lenticular design can be made thinner than a single cut design.

This study attempts to show the differences in centration and movement of low plus lenses (+3.00D) using regular and minus carrier lenticulars verses single cut lenses. The design of a low plus lens is an important factor in the way the lens fits on the eye.

Methods

Lens Design Classification

The optical zone of a contact lens contains the refractive power and overlies the central corneal zone. The anterior optical portion (or optic cap) of a single cut lens covers the entire front surface of the lens. By reducing the optic cap (lenticular design) the center thickness is less than with a single front curve (Figure 1 a, b, and c). With a regular carrier lenticular the anterior peripheral radius approximately parallels the back surface (figure 1 b). The mass of the lens is decreased therefore allowing better centration. The minus carrier lenticular also has a reduced optic cap however, the carrier portion is in the shape of a wedge (Figure 1 c). The force of the upper lid grabs ahold of the carrier and helps to hold up the lens.

Using a computer aided design program by Gerald E. Lowther, O.D., PhD, we designed a trial lens fitting set consisting of +3.00 single cut lenses, +3.00 regular carrier lenticulars, and +3.00 minus carrier lenticulars. Tables 1, 2, and 3 list the lenses in the fitting set.

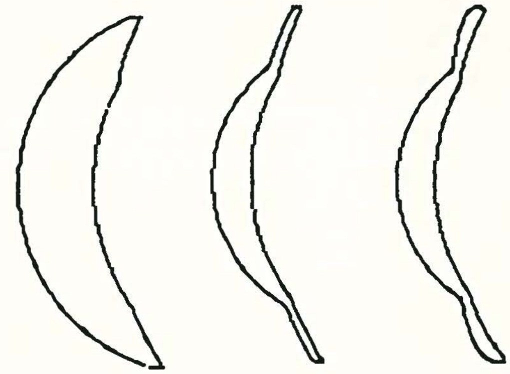

Figure 1: (a) single cut lens; (b) regular carrier lenticular; (c) minus carrier lenticular

Procedure

Nine subjects (eighteen eyes) were selected from the faculty and students at Ferris State University's College of Optometry. They were required to have less than two diopters of corneal cylinder. An Allergan Humphrey Auto Keratometer was used to obtain keratometric readings. The lenses were fit on the flattest keratometry reading. One drop of Alcaine (0.5% Proparacaine Hydrochloride) was instilled before the lenses were placed on the eye.

A Sony Video Camera (model number CCD) was attached to a Topcon Slit Lamp (SL-6E) and used with a millimeter ruler to evaluate lens centration and movement. Using a video cassette recorder with slow-motion capability, the lens movement and centration were averaged on two separate occasions by the student author and two optometrists.

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1 Guillon M, Lydon D. Tear Layer Thickness Characteristics of Rigid Gas Permeable Lenses, Am J Optom 1986; 63 (7): 527-535.

2 Barr JT. Hard contacts lens fitting guidelines. In: Barr JT,ed. Contact Lens Pocket Guide 1st Ed., Allergan Optical, 1987: 35-64.

Table 1: Single Cut Plus Lenses

Overall Diameter=9.5 Optic Zone Diameter=8.0 Power=+3.00D

Base Curve Radius (mm)	Secondary Curve Radius (mm)	Tertiary Curve Radius (mm)	Tertiary Curve Width (mm)	Center Thickness (mm)
8.30	9.50	12.00	0.2	0.28
8.20	9.40	12.00	0.2	0.28
8.10	9.30	11.00	0.2	0.28
8.00	9.20	11.00	0.2	0.29
7.90	8.90	11.00	0.2	0.28
7.80	8.80	11.00	0.2	0.29
7.70	8.70	11.00	0.2	0.29
7.60	8.60	11.00	0.2	0.30
7.50	8.50	11.00	0.2	0.30
7.40	8.40	11.00	0.2	0.31

Table 2: Regular Carrier Lenticulars

Overall Diameter=9.5 Optic Zone Diameter=8.0 Front Optic Zone Diameter=8.10
Power=+3.00D Junction Thickness=.13

Base Curve Radius (mm)	Secondary Curve Radius (mm)	Tertiary Curve Radius (mm)	Tertiary Curve Width (mm)	Center Thickness (mm)
8.30	9.50	12.00	0.2	0.19
8.20	9.40	12.00	0.2	0.19
8.10	9.30	11.00	0.2	0.19
8.00	9.20	11.00	0.2	0.19
7.90	8.90	11.00	0.2	0.19
7.80	8.80	11.00	0.2	0.19
7.70	8.70	11.00	0.2	0.19
7.60	8.60	11.00	0.2	0.19
7.50	8.50	11.00	0.2	0.19
7.40	8.40	11.00	0.2	0.19

Table 3: Minus Carrier Lenticulars

Overall Diameter=9.5 Optic Zone Diameter=8.0 Front Optic Zone Diameter=8.10
Power=+3.00D Junction Thickness=.13

Base Curve Radius (mm)	Secondary Curve Radius (mm)	Tertiary Curve Radius (mm)	Tertiary Curve Width (mm)	Center Thickness (mm)
8.30	9.50	12.00	0.2	0.19
8.20	9.40	12.00	0.2	0.19
8.10	9.30	11.00	0.2	0.19
8.00	9.20	11.00	0.2	0.19
7.90	8.90	11.00	0.2	0.19
7.80	8.80	11.00	0.2	0.19
7.70	8.70	11.00	0.2	0.19
7.60	8.60	11.00	0.2	0.19
7.50	8.50	11.00	0.2	0.19
7.40	8.40	11.00	0.2	0.19

Results

The results of the centration, palpebral aperture, base curve radius and movement for the subject's right and left eyes are illustrated on Table 4.

The mean vertical (superior and inferior) centration for the regular carrier lenticular was .028mm superior with a standard deviation of .363 (range 0.0mm to 1.0mm). The mean horizontal (temporal and nasal) centration was .139mm temporal with a standard deviation of .287 (range 0.0mm to 1.0mm). The mean movement was +.806 mm with a standard deviation of .339 (range 0.0mm to +1.50mm).

The minus carrier lenticular had a mean vertical centration of .111mm inferior with a standard deviation of .366 (range 0.0mm to 1.0). The mean horizontal centration was .139mm temporal with a standard deviation of .447 (range 0.0mm to 1.0mm). The mean movement was +.706mm with a standard deviation of .333 (range 0.0mm to +1.50mm).

Finally, the mean vertical movement of the single cut design was .944mm inferior with a standard deviation of .820 (range 0.0mm to 3.00mm). The mean horizontal movement was .042mm temporal with a standard deviation of .346 (range 0.0mm to .75mm). The mean movement was +1.11mm with a standard deviation of .896 (range 0.0mm to +3.00mm).

Discussion

There was a .689 correlation between the vertical centration of the regular carrier lenticular and the minus carrier lenticular. Minimal correlation existed for vertical centration of the single cut lenses and the lenticulars. Also, there was minimal correlation in movement and horizontal centration between any of the lenses.

The mean horizontal and vertical centration of both lenticular designs was less than .14mm in any direction, while the mean vertical centration of the single cut lenses was .944mm inferior. A lens centering inferiorly greater than or equal to 1mm indicated a lens edge at or below the lower lid margin. The mean vertical centration of the single cut lenses indicated a lens centering just above the lower lid margin. The lenticular designed lenses were held up underneath the upper lid, while the single cut lenses were forced out from under the upper lid because their increased center thickness. This is known as the "watermelon seed effect." A low riding lens frequently causes 3 and 9 o'clock staining because of a suppressed or incomplete blink.

Adequate lens movement for a gas permeable lens is between 1.0-2.0mm. The mean lenticular lens movement was slightly less than what would be adequate. When necessary, the lens movement can be increased by flattening the base cure radius or decreasing the overall lens diameter. The mean movement of the single cut lenses was adequate.

Conclusion

For low plus lenses, regular or minus carrier lenticulars. would be the lens design of choice. Lenticular lens designs enable the practioner to use a larger diameter lens and provide better centration. Overall, the lenticulars had less movement following a blink than the single cut lenses.

Acknowledgments

Thanks to Duane Tracy and Paragon Optical for providing the lenses for this study.

Table 4: Results of Fit of Three Different Lens Designs in Millimeters

	Regular Carrier Lenticular OD	Minus Carrier Lenticular OD	Single Cut OD	Regular Carrier Lenticular OS	Minus Carrier Lenticular OS	Single Cut OS
Centration	1.0 Temporal.	1.0 Temporal	2.0 Inferior	Centered	Centered	1.0 Inferior
Aperture	8.0	8.0	8.0	8.0	8.0	8.0
B.C.R.[1]	7.6	7.6	7.6	7.6	7.6	7.6
Movement	+0.50	+0.50	+2.0	+0.50	+0.75	+2.0
Centration	Centered	1.0 Temporal	2.0 Inferior	.50 Temporal	Centered	3.0 Inferior .50 Nasal
Aperture	8.5	8.5	8.5	8.5	8.5	8.5
B.C.R.	7.8	7.8	7.8	7.8	7.8	7.8
Movement	+1.50	+1.0	+2.0	+0.75	+1.0	0.0
Centration	.50 Superior	Centered	1.50 Inferior	1.0 Superior	.50 Superior	1.0 Inferior
Aperture	8.0	8.0	8.0	8.0	8.0	8.0
B.C.R.	7.6	7.6	7.6	7.6	7.6	7.6
Movement	+1.0	+0.50	+2.0	+1.0	+0.75	+3.0
Centration	.50 Temporal	Centered	1.0 Inferior	Centered	Centered	1.0 Inferior
Aperture	9.0	9.0	9.0	9.0	9.0	9.0
B.C.R.	8.0	8.0	8.0	8.0	8.0	8.0
Movement	+0.75	+0.50	0.0	+1.0	+0.75	0.0
Centration	Centered	1.0 Temporal	1.0 Inferior	Centered	.50 Temporal	.75 Temporal
Aperture	8.0	8.0	8.0	8.0	8.0	8.0
B.C.R.	7.9	7.9	7.9	8.0	8.0	8.0
Movement	+0.50	+0.50	+1.00	+0.50	+0.50	+0.50
Centration	Centered	Centered	.50 Temporal	Centered	Centered	1.0 Inferior
Aperture	9.0	9.0	9.0	9.0	9.0	9.0
B.C.R.	7.7	7.7	7.7	7.6	7.6	7.6
Movement	+1.50	+1.0	+1.50	+1.0	+1.50	+1.0
Centration	Centered	Centered	.50 Nasal	.50 Temporal	Centered	.50 Temporal
Aperture	6.0	6.0	6.0	6.0	6.0	6.0
B.C.R.	7.6	7.6	7.6	7.6	7.6	7.6
Movement	+0.25	+0.50	+0.25	+0.75	+0.50	+0.50
Centration	Centered	Centered	Centered	Centered	.50 Inferior	.50 Inferior .50 Temporal
Aperture	8.0	8.0	8.0	8.0	8.0	8.0
B.C.R.	7.4	7.4	7.4	7.5	7.5	7.5
Movement	+1.0	+0.75	+1.0	+1.0	0.0	+2.0
Centration	1.0 Inferior	1.0 Inferior .50 Nasal	1.0 Inferior .50 Nasal	Centered	1.0 Inferior .50 Nasal	1.0 Inferior
Aperture	8.0	8.0	8.0	8.0	8.0	8.0
B.C.R.	7.4	7.4	7.4	7.4	7.4	7.4
Movement	0.0	+1.0	+1.0	+1.0	0.0	+0.25

[1]Base Curve Radius