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The role of index of refraction in the power of rigid gas permeable contact lenses

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Pacific University

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Abstract
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Patrick Caroline

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The Role of Index of Refraction in the Power of Rigid Gas Permeable Contact Lenses

Justin Mans

A THESIS SUBMITTED TO THE FACULTY OF THE COLLEGE OF OPTOMETRY PACIFIC UNIVERSITY FOREST GROVE, OREGON FOR THE DEGREE OF DOCTOR OF OPTOMETRY MAY 2007

ADVISOR:

Pat Caroline
Thesis Title:
The Role of Index of Refraction in the Power of Rigid Gas Permeable Contact Lenses

By:
Justin Mans and Pat Caroline

Thesis Supervisor:  
Patrick Caroline

Student:  
Justin Mans
Biography

Justin Mans:

I am currently a fourth year student at Pacific University College of Optometry. I received a bachelor of science from University of Oregon in general science with a minor in chemistry. Upon graduation I plan to practice at a private group practice in Florence Oregon.
Introduction:

The purpose of this study was to determine what the role of the index of refraction for different materials plays on power of an RGP contact lens. The study looked at both single vision RGP's of two different materials and also Aspheric RGP's of two different materials.

An Aspheric RGP is any design of lens in which both the distance and near powers position in front of the pupil at the same time so that each contributes to the retinal image. No or limited movement of the lens is required. The patient sees multiple images at once which are focused and out of focus (Figure 1). At a given distance, the brain selects the appropriate image to focus on. The Aspheric RGP's are fit about 3 diopters steeper than K to get vaulting at the central cornea. This induces a positive lacrimal lens behind the RGP lens which is compensated for by making the lens power more negative.

Figure 1: A spherical RGP lens
Figure 2: An Aspheric RGP lens.

Aspheric RGP’s have a center for distance which is opposite of what a soft aspheric lens has (Figure 3). This is because RGP aspheric lenses move more than their soft lens counterparts and their upward translation in downgaze helps to move their peripheral near optics into the pupillary zone. If the near zone were to be located centrally, the upward movement in downgaze would displace the near optics superiorly and bring the intermediate and distance portions of the lens into the pupillary zone, affecting near vision significantly.
Material and Methods:

First: IDENTICAL, single vision lenses with exactly the same anterior and posterior curves, in the following plastics.

- PMMA (index 1.490)
- Boston XO (index 1.415)

Both lenses would have the same posterior radius (43.00) and the exact same anterior radius. If the calculations are correct, when the resulting lenses are placed into the lensometer, the PMMA lens should read more plus power than the Boston XO.

This was also done with a generic posterior, aspheric multifocal design (with a posterior asphericity of 0.80) with the specification of such a design in PMMA (right lens) and Boston XO (left lens).
Material PMMA (index 1.490)

<table>
<thead>
<tr>
<th>Center Thickness Power</th>
<th>Anterior Curve</th>
<th>Posterior Curve</th>
<th>Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.19</td>
<td>7.95 mm</td>
<td>7.89 mm</td>
<td>Plano</td>
</tr>
<tr>
<td>0.15</td>
<td>8.321 mm</td>
<td>7.89 mm</td>
<td>-3.00</td>
</tr>
<tr>
<td>0.12</td>
<td>8.725 mm</td>
<td>7.89 mm</td>
<td>-6.00</td>
</tr>
<tr>
<td>0.20</td>
<td>7.637 mm</td>
<td>7.89 mm</td>
<td>+3.00</td>
</tr>
<tr>
<td>0.28</td>
<td>7.348 mm</td>
<td>7.89 mm</td>
<td>+6.00</td>
</tr>
</tbody>
</table>

In manufacturing the (control) PMMA lenses it is imperative that the combination of the anterior and posterior radii yield the exact, expected powers of Plano, -3.00, -6.00, +3.00 and +6.00.

Material Boston XO (index 1.270)

<table>
<thead>
<tr>
<th>Center Thickness</th>
<th>Anterior Curve</th>
<th>Posterior Curve</th>
<th>Expected Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.19</td>
<td>7.95 mm</td>
<td>7.89 mm</td>
<td>???</td>
</tr>
<tr>
<td>0.15</td>
<td>8.321 mm</td>
<td>7.89 mm</td>
<td>???</td>
</tr>
<tr>
<td>0.12</td>
<td>8.725 mm</td>
<td>7.89 mm</td>
<td>???</td>
</tr>
<tr>
<td>0.20</td>
<td>7.637 mm</td>
<td>7.89 mm</td>
<td>???</td>
</tr>
<tr>
<td>0.28</td>
<td>7.348 mm</td>
<td>7.89 mm</td>
<td>???</td>
</tr>
</tbody>
</table>

In manufacturing the Boston XO lenses, the posterior radius should remain constant at 7.89 mm, and the center thickness and anterior radii should be IDENTICAL to those used with the PMMA lenses. In this way the power differences between the two materials (as measured in the lensometer) will be related to material index only.
Results:

The results of this study reveal two important findings, both with significant clinical implications:

#1. the higher index material (PMMA) yielded a significantly greater overall lens power, in both myopic and hyperopic corrections.

#2. The differences in resultant lens powers appeared to change in a linear fashion with increasing myopic and hyperopic corrections.

These results validate the hypothesis that higher index RGP materials can provide additional add power in aspheric multifocal lenses.

Myopic Corrections
+0.25 D. increased add with a plano lens power
+0.50 D. increased add with a -3.00 D. lens power
+1.00 D. increased add with a -6.00 D. lens power

Hyperopic Corrections
+0.25 D. increased add with a plano lens power
+0.50 D. increased add with a +3.00 D. lens power
+1.12 D. increased add with a +6.00 D. lens power
Aspheric AEL
RIGHT
+2.25 B PMMA
Mer~ Verte
xo 8
+1.00
Prolate Fl.it Steep Fl.it Steep
Prolate
0.80 7.35 7.35 0.80
-5.50 10.0 Flatter
Sphere Steeper Alt. PCs
Alt. PCs 10.0 Flatter
8.6
Base Curve / Ecc Power / Ecc Center Thickness Diameter Back OZ
XO B +1.00
Flat Steep Prolate
7.35 0.13 Steeper 10.0 Flatter
8.6 Alt. PCs

Tear Profile Beneath Both Right and Left Lenses
Mid-Peripheral Alignment
Central Apical Clearance
Mid-Peripheral Alignment

PosterioRadius = 42.75 (7.90)
Conclusions:

The results of the experiment came out exactly as expected. The PMMA lenses which have a higher index of refraction had a higher power than the Boston XO lenses. With both lenses being exactly the same lens, just different material with a different index of refraction, this proves that the index of refraction plays a role in the power of the lens.

The same was true for the aspheric lenses. The aspheric PMMA lens which has a higher index of refraction had a higher power than the aspheric Boston XO lens. Both lenses were identical other than the material just like the spherical RGP’s used in the study. The following is a list of different materials used in the production of RGP lenses and the corresponding index of refraction.

<table>
<thead>
<tr>
<th>Lens Material</th>
<th>Material Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMMA</td>
<td>1.490</td>
</tr>
<tr>
<td>SGP 2 &amp; 3</td>
<td>1.480</td>
</tr>
<tr>
<td>TransAir</td>
<td>1.475</td>
</tr>
<tr>
<td>Paraperm 02</td>
<td>1.473</td>
</tr>
<tr>
<td>Boston IV</td>
<td>1.468</td>
</tr>
<tr>
<td>Paragon HDS 100</td>
<td>1.453</td>
</tr>
<tr>
<td>Contamac Classic</td>
<td>1.450</td>
</tr>
<tr>
<td>Paragon HDS</td>
<td>1.449</td>
</tr>
<tr>
<td>Boston ES</td>
<td>1.443</td>
</tr>
<tr>
<td>Menicon Z</td>
<td>1.440</td>
</tr>
<tr>
<td>Contamac Comfort</td>
<td>1.440</td>
</tr>
<tr>
<td>Boston RXD</td>
<td>1.435</td>
</tr>
<tr>
<td>Contamac Extra</td>
<td>1.430</td>
</tr>
<tr>
<td>Contamac Extreme</td>
<td>1.430</td>
</tr>
<tr>
<td>Boston EO</td>
<td>1.429</td>
</tr>
<tr>
<td>Boston XO</td>
<td>1.415</td>
</tr>
</tbody>
</table>

Summary:

This study was done to prove that index of refraction plays a role in the power of a lens. Although it has been known that index of refraction determines how much light is bent through a transparent medium, it has never been shown through RGP lenses. It was felt that this is an important thing to prove in a study because millions of people wear RGP lenses.
By using two lenses that were built to be exactly the same except for the material, we were able to show with a lensometer that the higher the index of refraction the more power the lens has.