ABSTRACT

Purpose: To evaluate the impact of disposable soft contact lenses upon visual performance by comparing the optical aberrations of myopic eyes with and without the use of contact lenses.

Method: The optical aberrations of a set of 18 eyes were measured by a laser ray tracing system, an objective measurement method, enabling comparison of the findings of the naked eye, the eye plus a test lens, and the eye plus a disposable contact lens.

Results: There was a large variability among subjects, but the general tendency was that test lenses did not modify aberrations, whereas contact lenses tended to increase the ocular aberrations for large pupils by an average of 40%. There was a lower increase for smaller pupils.

Conclusion: This study predicts there will be no significant adverse effects on the quality of vision from the use of disposable contact lenses worn under daylight conditions, but a small decline in night vision (Arch Soc Esp Oftalmol 2006; 81: 575-580).

Key words: Aberrations, soft contact lenses, Laser Ray Tracing.

RESUMEN

Objetivo: Evaluar el impacto de las lentes de contacto desechables en la calidad visual, comparando aberraciones ópticas, en ojos miopes, con y sin lentes de contacto.

Método: Las aberraciones ópticas se midieron mediante el sistema del Trazado de Rayos Láser, el cual es un método de medida objetivo, sobre un conjunto de 18 ojos, en 3 condiciones diferentes: a ojo desnudo, ojo más lentes de prueba, ojo con lentes de contacto desechables.

Resultados: Existe una alta variabilidad entre sujetos, pero la tendencia general es que las lentes de prueba no modifican las aberraciones, mientras que las lentes de contacto tienden a incrementar las aberraciones oculares para pupilas grandes cerca de un 40% en promedio. Sin embargo tal incremento es mucho menor para pupilas más pequeñas.

Conclusión: Este estudio revela que no se producen efectos significativos en la calidad de visión en pacientes que usan lentes de contacto desechables bajo condiciones de luz diurna, así como un pequeño descenso en visión nocturna.

Palabras clave: Aberraciones, lentes de contacto blandas, método de trazado de Rayos.
INTRODUCTION

Today, ametropia may be corrected using glasses, contact lenses (CL) or refractive surgery. Doctors must inform their patients about the existing pros and cons of all three methods, so that patients may be capable of making the most adequate choice based on their specific needs. Since all of the above methods correct ametropia (out-of-focus vision and/or astigmatism) directly, it is important to follow certain criteria in order to choose the best solution for each particular individual.

In cases of moderate ametropia, conventional glasses will not alter optical aberrations significantly due to its relatively low numerical aperture (low aberrations); and, since they do not impact the eye directly, neither do they alter its geometry. Nevertheless, refractive surgery techniques seem to increase optical aberrations by 2 (1) and even by 4 (2). As for CLs, recent studies have pointed out the presence of several factors affecting visual quality such as tear film, dynamics of the lens itself, time, age, lens hydration and flexibility, as well as the lens manufacturing process and changes in ocular aberrations due to adjustment (3,4).

Few studies have analysed the optical quality of the system made up by the eye plus the contact lens using objective parameters based on the Modulation Transfer Function (5,6), which is found by using a double-step method (7,8). Generally, previously published studies assessed optical compensation via CL exclusively focusing on subjective techniques such as visual acuity (VA) or the Contrast Sensitivity Function (CSF). Furthermore, most studies only focused on rigid gas permeable (RGP) contact lenses. There is high variability as far as the findings published in literature goes, where the differences observed were usually not significant. Some of these studies found that RGP contact lenses improved visual quality by reducing corneal aberrations, whereas a few studies have reported slight improvements as a result of using soft contact lenses. Other authors stated that improvement of visual quality through the use of CLs varied and depended to a certain extent on their own nature (9-19).

The department in charge of Image and Vision at the Instituto de Óptica (CSIC, Madrid, Spain) has received worldwide recognition for its contribution in the field of physiological optics and vision. In both basic and clinical studies, several methods devised by this laboratory were successfully applied to measure optical quality of the eye in vivo. One of those methods, known as Laser Ray Tracing (LRT), measures in an objective manner optical aberrations (9) in the eye and was the method chosen for the present study.

SUBJECTS, MATERIAL AND METHODOLOGY

The present research complied with the postulates contained in the Declaration of Helsinki and thus all subjects signed the corresponding informed consent forms after being briefed on the nature and possible consequences of the study.

Material

Disposable CLs were chosen for the present study; weekly CLs in case of prolonged use and bi-weekly contact lenses in case of daily use. CLs were hydrophilic, with 58% humidity, radius ranging from 8.30 to 8.70 mm.

Subjects

The subjects were 10 myopic volunteers (18 eyes) free of ocular disorders susceptible of triggering intolerance to contact lenses. Six (6) females and 4 men, ages ranging from 22 and 27 years. Refractive errors went from −.75 and −7.00 D. Table I summarizes the data concerning these subjects in ascending order based on myopia values.

Methodology

Eye Exam

All subjects underwent optometric and ophthalmic examinations which entailed measuring ametropia, adjustment to contact lenses, and a study of ocular health (measuring eye pressure, performing a slit lamp study, measuring the iridocorneal angle, studying the eye fundus whenever necessary, reviewing the patient’s history, high ametropia, etc). At least two days were allowed between the time of adjustment to contact lenses and that of the experiment.
Measuring Objective Ocular Aberration

Optical quality in each eye was measured via LRT, the method devised by the Instituto de Óptica (CSIC) to objectively measure optical aberrations (9). A narrow laser beam (ray) was directed at several spots on the retina; the positioning of the light spots formed by each beam was then recorded; differences between theoretical locations and those actually found yielded an estimated aberration revealed by the light’s wave-front when traversing the eye (1,14).

Measurements were performed when at least two of the following conditions were detected in each eye:
1. No correction (naked eye), the exception being those subjects with more than 4 diopters, since higher myopia values could exceed the LTR’s measurement range.
2. Test lenses helped estimating the optical quality achieved with glasses. Due to the different models available, test lenses were chosen in order to standardize results. Measurements were performed in most cases, though only when the first case proved hopeless.
3. In all cases, the CL to be assessed. In each case, measurements were repeated 5 times.

The subjects did not wear CLs for at least 48 hours prior to measurement. Soft CLs were worn at least 30 minutes prior to measurement in order to allow for full eye stabilization.

Data Analysis

Wave aberration may be characterized as a 7th order Zernike polynomial expansion (35 coefficients). The average set of Zernike coefficients was estimated through adjustment of the data yielded by all five measurements taken for each condition; therefore, these coefficients described the optical aberrations found. The root-mean-square (RMS) for these coefficients (RMS for the wave-front error) was used to measure the eye’s global optical quality, or that of the optical system formed by eye plus lens (be it contact or test lens).

Measurements were performed on a 6.5 mm pupila obtained through dilation with cyclopegic drugs, although Zernike coefficients were again recalculated based on a 3 mm pupil.

In order to assess whether these results were statistically significant or not, a Paired-Samples T-Test with a 95% confidence level (\( \alpha = .05 \)) was performed.

FINDINGS

Figure 1 shows the RMS for wave-front error, not taking into account out-of-focus vision and astigmatism (that is, only 3rd order aberrations or higher), for 18 eyes and 6.5 mm pupilas: uncorrected eyes (SC, white bars); eyes wearing test lenses (LP, black bars) and CL users (CL, bars with diagonal grey lines). The data were classified based on myopia values (in ascending order). Eyes 1 to 16 showed spherical myopic errors ranging from .75 to 3.50 D, whereas eyes 17 and 18 exhibited errors up to 7 D, as seen in Table 1 above.

As for the aberrations measured, results varied greatly from one eye to the other. On average, test lenses tended to slightly reduce optical aberrations and to increase optical quality.

For CLs, several groups were observed: Eyes (1-8) with refractive errors less than or equal to 2.00 D; CLs increased aberrations in all cases. On the other hand, 70% of eyes with refractive errors greater than 2.50 D (eyes 9-18) improved their optical quality using CLs. When applying the Paired-Samples T-Test, the p-value obtained was .0092 when comparing distributions for RE and LC, and p-value=.0229 for distributions of RE and LC. Both were greater than \( \alpha = .05 \) (95% confidence), so results were statistically significant.

Table II shows average results for different aberrations.
As expected, test lenses did not significantly alter eye aberrations, though results revealed a slight improvement. On the other hand, on average, CLs increased optical aberrations in 40% of cases. Nevertheless, it is worth mentioning that standard deviations were always significantly greater than the average, indicating high variability and different behaviour for each individual eye (20). There was also a strong dependency on the size of the pupila: while the increase of optical aberrations was potentially greater for large pupillas (6.5 mm), values found for smaller pupillas (3 mm) were much lower.

**DISCUSSION**

Results obtained using the LTR method predicted an effect on visual quality which was negligible in the case of disposable CLs under conditions of natural daylight (the pupilla’s diameter being not much greater than 3 mm), and yet a moderate decrease in visual quality during night vision or with low light levels (approximately 6.5 mm pupillas), while test lenses did not alter visual quality. Nevertheless, it is important to point at the high variability of results found for different eyes (20). The present study should be considered as a pilot experiment and further studies will be needed to determine the causes of such big differences, including a greater number of patients and different brands of CLs as well as additional parameters in order to perform more accurate adjustments.

**ACKNOWLEDGEMENTS**

The present study was partially funded by the CICYT (Ministry of Education and Science) under TIC 98-0925-CO2-01. The authors wish to express their gratitude to the Unidad Asociada de Investigación IOBA (University of Valladolid), Instituto de Óptica (CSIC), and Unidad de Contactología del Centro de Especialidades Oftalmológicas de Madrid for their contribution; and to Ms. Lourdes Llorente (Instituto de Óptica, CSIC) for her technical assistance.

**Table I. Optometric Data for the Eyes**

<table>
<thead>
<tr>
<th>Eye</th>
<th>Refraction (D)</th>
<th>Keratometry (mm)</th>
<th>Biomicroscopy</th>
<th>Comfort wearing contact lenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>−.75</td>
<td>8.16 × 8.01</td>
<td>Reddening</td>
<td>Slight discomfort</td>
</tr>
<tr>
<td>2</td>
<td>−.75</td>
<td>8.14 × 8.00</td>
<td>Reddening</td>
<td>Slight discomfort</td>
</tr>
<tr>
<td>3</td>
<td>−1.50</td>
<td>8.04 × 7.87</td>
<td>OK</td>
<td>Comfortable</td>
</tr>
<tr>
<td>4</td>
<td>−1.50</td>
<td>7.96 × 7.76</td>
<td>OK</td>
<td>Comfortable</td>
</tr>
<tr>
<td>5</td>
<td>−1.50</td>
<td>7.94 × 7.73</td>
<td>OK</td>
<td>Comfortable</td>
</tr>
<tr>
<td>6</td>
<td>−1.50</td>
<td>7.72</td>
<td>OK</td>
<td>Comfortable</td>
</tr>
<tr>
<td>7</td>
<td>−1.50</td>
<td>7.82</td>
<td>OK</td>
<td>Comfortable</td>
</tr>
<tr>
<td>8</td>
<td>−2.00</td>
<td>8.17 × 8.03</td>
<td>Reddening</td>
<td>Comfortable</td>
</tr>
<tr>
<td>9</td>
<td>−2.50</td>
<td>7.55 × 7.43</td>
<td>Reddening</td>
<td>Slight discomfort</td>
</tr>
<tr>
<td>10</td>
<td>−2.50</td>
<td>8.25 × 8.09</td>
<td>Reddening</td>
<td>Slight discomfort</td>
</tr>
<tr>
<td>11</td>
<td>−2.75</td>
<td>7.81 × 7.73</td>
<td>OK</td>
<td>Comfortable</td>
</tr>
<tr>
<td>12</td>
<td>−2.75</td>
<td>7.70 × 7.60</td>
<td>OK</td>
<td>Comfortable</td>
</tr>
<tr>
<td>13</td>
<td>−2.75</td>
<td>7.76 × 7.71</td>
<td>OK</td>
<td>Slight discomfort</td>
</tr>
<tr>
<td>14</td>
<td>−2.75</td>
<td>7.76 × 7.71</td>
<td>OK</td>
<td>Slight discomfort</td>
</tr>
<tr>
<td>15</td>
<td>−2.75</td>
<td>7.70 × 7.6</td>
<td>OK</td>
<td>Comfortable</td>
</tr>
<tr>
<td>16</td>
<td>−3.50</td>
<td>7.60 × 7.52</td>
<td>Reddening</td>
<td>Comfortable</td>
</tr>
<tr>
<td>17</td>
<td>−5.25</td>
<td>7.53 × 7.44</td>
<td>OK</td>
<td>Comfortable</td>
</tr>
<tr>
<td>18</td>
<td>−7.00</td>
<td>7.59 × 7.35</td>
<td>OK</td>
<td>Comfortable</td>
</tr>
</tbody>
</table>

**Table II. Average Increase of RMS in Uncorrected Eyes**

<table>
<thead>
<tr>
<th>RMS Variation (mm)</th>
<th>Pupila 6.5 mm</th>
<th>Pupila 3 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test Lenses</td>
<td>Contact Lens</td>
</tr>
<tr>
<td>Global (3rd to 7th order aberrations)</td>
<td>−.06 SD .21</td>
<td>.20 SD .43</td>
</tr>
<tr>
<td>Coma (3rd order)</td>
<td>−.08 SD .21</td>
<td>.05 SD .28</td>
</tr>
<tr>
<td>4th order</td>
<td>.00 SD .10</td>
<td>.14 SD .30</td>
</tr>
</tbody>
</table>
REFERENCES


