A Comparison of Reading Performance in Patients Implanted with the Tecnis ZMA00 and AT LISA 802 Multifocal Intraocular Lenses

Werner W. Hütz, MD1; Jürgen Kerbs, MD1; Peter C. Hoffmann, MD2; Ina Conrad-Hengerer, MD3; Fritz Hengerer, MD3

PURPOSE: To evaluate and compare reading performance under bright and low-light conditions following the implantation of two different multifocal intraocular lenses (IOLs).

METHODS: Randomized, prospective study. Thirty cataract patients (60 eyes) were randomly assigned for implantation with either the Tecnis ZMA00 (AMO) (Group 1, 15 patients) or the AT LISA 802 (Zeiss) (Group 2, 15 patients) IOL. Patients’ reading ability (visual acuity, reading speed) was assessed 12 weeks postoperatively under low-light (6 cd/m²) and bright-light conditions (100 cd/m²). Contrast sensitivity (CS) and refractive results were also analyzed.

RESULTS: Twelve weeks postoperatively, under low-light conditions, patients in Group 1 had a mean binocular reading speed of 135.9±29.8 words per minute (wpm) while Group 2 had 106.1±29.8 wpm (p=0.007). Under bright-light conditions, reading speeds were 165.9±25.8 and 148.4±31.8 wpm in Groups 1 and 2 respectively. CS results revealed comparable contrast levels in both groups under bright-light conditions, but superior levels in Group 1 under low-light conditions, with a statistically significant difference at the highest spatial frequency (18 cpd, p=0.046). Visual acuity results revealed no statistically significant differences between the two groups, but significantly better spherical correction was achieved in Group 1 (p=0.004).

CONCLUSION: While outcomes in visual acuity and reading performance in bright-light conditions were comparable in the two groups, in low-light conditions patients in Group 1 achieved significantly superior reading speeds and better CS at the highest spatial frequency. This suggests that overall reading performance was significantly better with the Tecnis ZMA00 than with the AT LISA 802.

KEYWORDS: Reading performance, multifocal IOL.

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tion multifocal IOLs can be diffractive and pupil-independent, providing excellent near and intermediate vision with reduced optical phenomena. In addition, spectacle independence and higher patient satisfaction appears more frequently in patients implanted with multifocal IOLs than those with monofocal IOLs.

A comprehensive comparison of all the advantages and disadvantages of different types of IOL would be taxing and somewhat repetitive of previously published literature, but a focus on a particular aspect of the effect of different types of IOL on patients’ visual abilities warrants significant attention. Studies have reported that patients’ quality of life can be significantly reduced through the loss of reading ability. Therefore it is important that optimal reading ability is achieved when treating the cataract patient, which can be measured by considering reading acuity, reading speed and CS – component aspects to one’s ability to read adequately.

Comparisons of reading ability using different IOLs have shown that first-generation multifocal IOLs have performed inferiorly to second-generation multifocal IOLs under bright-light conditions, while a comparison of early generation diffractive bifocal and refractive multifocal IOLs showed the former to provide better reading performance results than the latter in a standard multifo- cal IOL under bright-light conditions, while a comparison of early generation diffractive bifocal and refractive multifocal IOLs showed the former to provide better reading performance results than the latter in a standardized reading test setting. In an evaluation of an aspheric IOL by Peters et al., the latter in a standardized reading test setting. In an evaluation of an aspheric IOL by Peters et al., the former yielded superior results in terms of reading performance, as measured by acuity and speed. Meanwhile, Brown et al. showed superiority in reading ability results for the Tetraflex accommodating IOL (Lenstec, Inc., St. Petersburg, FL) over the Crysta lens IOL (Bausch + Lomb, Rochester, NY), exemplifying the variability of results achieved with accommodative lenses.

The impact of different lighting conditions is an important consideration when selecting IOLs on the basis of reading ability. Aspheric IOLs have been shown to produce improved functional vision results compared with spherical IOLs, with lower ocular spherical aberration and better CS under scotopic conditions. Also, while spherical multifocal IOLs have performed inferiorly to monofocal IOLs with regard to CS, aspheric multifocal IOLs have achieved superior results. It is widely acknowledged that CS negatively correlates with the progression of age, owing to spherical aberration, and that spherical IOLs do not address spherical aberration as do aspheric IOLs. Some multifocal IOLs have been reported to be distance-biased; whereas distance CS might be within the normal range under photopic conditions, there can be some deficiency at higher spatial frequencies under low-light conditions and near CS can be relatively low compared with results achieved with monofocal near correction.

Although the options are vast, it is apparent from the aforementioned studies that the aspheric multifocal IOL is particularly effective when considering patients’ reading ability under varying lighting conditions as a primary concern. In this study, we compare the reading ability results of patients in different lighting conditions following bilateral implantation of one of two diffractive aspheric multifocal IOLs, and to identify the differences, if any, between them.

**METHODS**

In this randomized prospective study, 30 cataract patients (60 eyes) were assigned to be implanted bilaterally with one of two multifocal intraocular lenses: the Tecnis ZMA00 (Abbott Medical Optics, Santa Ana, California, USA) (Group 1, 15 patients) or the AT LISA 802 (Carl Zeiss AG, Jena, Germany) (Group 2, 15 patients). The Tecnis ZMA00 is a full-surface diffractive aspheric multifocal IOL with a 6.00 mm optic and an add power of +4.00 diopters (D). The AT LISA 802 is a refractive–diffractive aspheric multifocal IOL also with a 6.00 mm optic and an add power of +3.75 D on the IOL plane.

IOL power was calculated according to biometry results with the IOLMaster (Carl Zeiss AG, Jena, Germany) using the SRK/T formula. The next available diopter (plus) was chosen for implantation, and thus target refraction was emmetropia to slight over-correction.

All surgeries were performed by one experienced surgeon (W.W.) through random selection. A standardized cataract extraction procedure was used, with phacoemulsification performed through a 3.2 mm clear corneal incision. The multifocal IOLs were implanted in the capsular bag using the manufacturer’s recommended injector in each circumstance. Surgeries were

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1 Klinik für Augenheilkunde, Bad Hersfeld, Germany.
2 Laser- und Augenklinik Castrop-Rauxel, Castrop-Rauxel, Germany.
3 Klinik für Augenheilkunde, Ruhruniversität Bochum, Bochum, Germany.

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Corresponding author: Werner W. Hütz, Klinikum Bad Hersfeld GmbH, Augenklinik. Seilerweg 29. D-36251 Bad Hersfeld, Germany.
Email: werner.huetz@klinikum-hef.de or w.w.huetz@t-online.de
performed on the contralateral eye of each patient 14
days after the operation on their first eye. All patients
involved in the study gave their signed consent, and
IRB approval was received from the Freiburg Ethics
Commission.

Preoperatively and 12 weeks postoperatively,
patients had a complete ophthalmic examination,
including the assessment of near and distance visual
acuity with and without spectacle correction, refractive
evaluation and pupil size measurement under low-light
(6 cd/m²) and bright-light (100 cd/m²) conditions
using the millimeter scale of the Goldmann perimeter.
Patients’ reading speed was assessed as words per
minute (wpm) under low-light conditions and bright-
light conditions using the Radner Reading Charts.
These validated charts have been developed with
sentence optotypes in order to keep variations
minimal and to maintain constant geometric propor-
tions, thereby optimizing the accuracy of the reading
acuity measurements at all distances9,21. Within the
scope of this study, the smallest sized print that could
be read by patients and expressed in logRAD deter-
mined reading acuity measurements.

Text with a print size of logRAD 0.4 (Snellen 0.4,
generalized in newspapers and books) was used to
assess reading speed. Patients were asked to read the text
binocularly as quickly and as accurately as possible,
reading one sentence at a time while the other sentences
were concealed. Reading speeds were expressed as wpm,
based on the number of words in a sentence and the
time spent to read it. Reading ability was tested without
correction and with best distance correction. CS was
assessed with a Ginsburg Functional Acuity Contrast
Test (FACT, Vision Sciences Research Corp.) chart,
under both lighting conditions at five spatial frequen-
cies [1.5, 3, 6, 12, and 18 cycles per degree (cpd)]. The
FACT system was used rather than the VectorVision
test system, owing to the latter’s relative insensitivity in
measuring contrast loss and gain22. CS is expressed in
logarithmic units using the log transformation and was
measured with corrected distance visual acuity (CDVA).

RESULTS

All surgeries were performed successfully, and no complications were recorded during or after surgery.

Refractive outcomes

Preoperatively, there were no statistically significant
differences between patients in Groups 1 (Tecnis) and
2 (AT LISA) with regard to ages, visual acuity and
refractive measurements (Table 1). But during the 12-
week postoperative follow-up, patients in Group 1 had
a mean reduction in spherical error from the preopera-
tive value of 0.858±1.935 dipters (D) to 0.033±0.536
D, while in Group 2 the mean sphere changed from
0.317±1.903 D preoperatively to 0.325±0.355 D post-
operatively. A statistically significant difference was
noted between the two groups postoperatively
(p=0.004). There were no other significant differences
between the two groups with regard to refractive out-
comes (Table 2).

Reading speed

Postoperatively, under low-light conditions, patients in Group 1 had a mean binocular reading speed of 135.9±29.8 wpm, compared with a binocular reading speed of 106.1 ± 29.8 wpm in Group 2, which was a statistically significant difference (p=0.007). Under bright-light conditions, the mean reading speed values were 165.9±25.8 and 148.4±31.8 wpm in
Groups 1 and 2, respectively (p=0.1352) (fig. 1,
table 3).

Table 1: Preoperative parameters of patients revealing no
statistically significant differences between Groups 1 and 2

<table>
<thead>
<tr>
<th></th>
<th>Group 1: Tecnis</th>
<th>Group 2: AT LISA</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>69 ± 8.9 (49 to 82)</td>
<td>69.2 ± 10.00 (53 to 90)</td>
<td>0.7951</td>
</tr>
<tr>
<td>CDVA logMAR</td>
<td>0.351 ± 0.195 (-0.10 to 0.70)</td>
<td>0.298 ± 0.254 (0.00 to 1.00)</td>
<td>0.0817</td>
</tr>
<tr>
<td>Sphere (Diopter)</td>
<td>0.858 ± 1.935 (-2.75 to 4.25)</td>
<td>0.317 ± 1.903 (-3.75 to 4.75)</td>
<td>0.1895</td>
</tr>
<tr>
<td>Cylinder (Diopter)</td>
<td>-0.617 ± 0.564 (-2.00 to 0.00)</td>
<td>-0.508 ± 0.397 (-1.25 to 0.00)</td>
<td>0.7235</td>
</tr>
<tr>
<td>Sph. Equiv. (Diopter)</td>
<td>0.552 ± 1.859 (-3.00 to 4.13)</td>
<td>0.090 ± 1.970 (-3.75 to 4.75)</td>
<td>0.1732</td>
</tr>
</tbody>
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CDVA = corrected distance visual acuity.
Contrast sensitivity

Tested at five spatial frequencies (1.5, 3, 6, 12, and 18 cpd), CS results yielded comparable contrast levels in the two groups under bright-light conditions (Table 4). However, superior CS results were achieved in Group 1 versus Group 2 under low-light conditions, and this superiority was statistically significant at the highest spatial frequency (18 cpd) with 1.57±1.17 versus 1.00±1.39 (log units) (table 5, fig. 2).

Visual acuity

From the preoperative examination to 12 weeks postoperatively, the mean CDVA improved from 0.351±0.195 to 0.06±0.077 logMAR in Group 1 and from 0.298±0.254 to 0.06±0.055 logMAR in Group 2. The change in CDVA is noted in Table 6. No statistically significant differences were noted in postoperative visual acuity results between the two groups (Table 7).
DISCUSSION

Since reading ability has a significant impact on quality of life, it is an important assessor of the capabilities of the intraocular lens. Standard measurers of visual function, such as Jaeger, Snellen, Birkhaeuser and Zeiss charts, are limited in their ability to only assess visual acuity rather than performance of real-life everyday tasks, and so performance-based tests have been designed for the simultaneous assessment of reading acuity and speed, which might be considered more reflective of simulating everyday tasks.

Within the scope of this study, the impact on patients’ reading ability of two aspherical multifocal IOLs was investigated, in order to identify any differences in the performance of the two lenses. The study showed that while refractive and visual acuity results were generally similar for patients implanted with the Tecnis ZMA00 and the AT LISA (except for the spherical error) it was with the Tecnis IOL that patients achieved significantly superior reading speeds in low-light conditions as well as better CS in low-light conditions. Since the postoperative spherical equivalents of the IOLs were not significantly different, the postoperative refractive quality of vision can be considered comparable in the two groups. The significant differences in binocular reading speeds and low-illumination CS cannot, therefore, be attributed to significant differences in postoperative refractive quality of vision.

The Tecnis ZMA00 features an aspheric anterior surface and fully diffractive posterior surface, which

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Figure 2. Contrast sensitivity results of the two IOL groups respectively, measured in low-light and bright-light conditions, reveal a considerable difference at the highest spatial frequency in low-light conditions.

| Table 6: The change in corrected distance visual acuity in Groups 1 and 2 compared |
|---------------------------------|-----------------|-----------------|--------|
|                                | Mean ± SD (Range) | Group 1: Tecnis | Group 2: AT LISA | P-value |
| CDVA logMAR Difference         | -0.287 ± 0.171   | -0.238 ± 0.260  | 0.0886 |
| CDVA = corrected distance visual acuity. |

| Table 7: Postoperative visual acuity results in Groups 1 and 2 compared |
|---------------------------------|-----------------|-----------------|--------|
|                                | Mean ± SD (Range) | Group 1: Tecnis | Group 2: AT LISA | P-value |
| UDVA* logMAR                   | 0.13 ± 0.077    | 0.14 ± 0.129   | 0.5414 |
| (0.00 to 0.30)                 | (-0.10 to 0.20) | (-0.10 to 0.40) |
| CDVA† logMAR                   | 0.06 ± 0.077    | 0.06 ± 0.055   | 0.5358 |
| (-0.10 to 0.20)                | (0.00 to 0.20)  |                  |
| UNVA§ logRAD                   | 0.16 ± 0.107    | 0.14 ± 0.114   | 0.6810 |
| (0.00 to 0.40)                 | (-0.10 to 0.30) |                  |
| DCNVA‡ logRAD                  | 0.13 ± 0.112    | 0.13 ± 0.079   | 0.5595 |
| (-0.10 to 0.30)                | (-0.10 to 0.20) |                  |

UDVA = Uncorrected distance visual acuity; CDVA = Corrected distance visual acuity; UNVA = Uncorrected near visual acuity; DCNVA = Distance corrected near visual acuity.
combine the advantages of reducing spherical aberrations and pupil-size independence, resulting in better reading capabilities under different lighting conditions. These combined principles enable better CS, especially in low-light conditions\(^\text{25,26}\), while achieving even light distribution, unlike multifocal IOLs based on principles of refraction. Meanwhile, the diffractive-refractive AT LISA features asymmetrical light distribution between distant (65%) and near (35%) focus, with the target of improving intermediate vision and reducing the incidence of halos and glare. The Tecnis ZMA00’s symmetrical light distribution targets distance and near vision, thereby enabling better reading performance in low-light conditions in addition to satisfactory results in bright-light conditions. This is consistent with a study by Richter-Mueksch\(^\text{8}\), which showed that superior reading speed results were achieved with a diffractive multifocal IOL compared with a refractive multifocal IOL.

The lower light level in the near focus (35%) due to the asymmetric light distribution may be the main factor contributing to the lower reading speed with AT LISA. While the maximum reading speed is used as a diagnostic clinical test with large print sizes, in this study we assessed the highest reading speed with smaller print sizes (of logRAD 0.4), as this size is reflective of texts read during everyday activities such as newspaper articles, books and magazines\(^\text{27}\).

Future studies might expand upon the variations of reading ability results using different multifocal IOLs considering the impact of different types and densities of cataract, which have been observed to affect reading performance\(^\text{2,28}\). Future investigations of reading performance after implantation of these multifocal intraocular lenses should include a quality of vision questionnaire.

REFERENCES


