Lens epithelial cell ongrowth: Comparison of 6 types of hydrophilic intraocular lens models

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PURPOSE: To compare the ongrowth of lens epithelial cells (LECs) on the anterior surface of 6 different hydrophilic intraocular lenses (IOLs).

SETTING: Medical University of Vienna, Department of Ophthalmology and Optometry, Vienna, Austria.

METHODS: Six models of hydrophilic IOLs were compared in this prospective study: Visionflex A-100 (Distra Softcryl), Rayner Centerflex 570H (Rayner), Collamer CC4204BF-IOL (Staar), Injectacryl F 3000 (Distra), Hydroview H60M (Bausch & Lomb), and MemoryLens (ORC). Postoperative biomicroscopic examinations were performed 1, 3, 7, 30, 90, 180, and 365 days after surgery. Lens epithelial cells in each quadrant of the anterior capsule–free lens surface were graded. The product with the highest density and the number of quadrants with this density were used to measure LEC ongrowth.

RESULTS: The Hydroview and Visionflex IOLs showed significantly more LECs than the other IOLs starting on day 7 after surgery ($P<.028$). There was a statistically significant difference in LEC ongrowth on the Memory IOL compared with all other IOLs from day 30 onward ($P<.001$). The Rayner, Collamer and Injectacryl IOLs had the fewest LECs on the anterior surface compared with all other IOLs from day 7 until the final examination.

CONCLUSIONS: The findings show that LEC ongrowth on the IOL surface is material dependent. The findings suggest that the material of the recently developed hydrophilic IOLs induces less LEC ongrowth than older models.


Several studies performed in the past few years show that the biocompatibility of an intraocular lens (IOL) depends on the reaction of the lens capsule and the uvea (uveal and capsule biocompatibility) to the implanted foreign body.1-6 The results of these studies clearly demonstrate better uveal biocompatibility and better capsule biocompatibility of hydrophobic acrylic IOLs.

Although the development of posterior capsule opacification is dependent on the lens material and the IOL design, anterior capsule opacification and lens epithelial cells (LEC) proliferation on the capsule-free anterior IOL surface are dependent on the material used.7,8

In the past few years, several hydrophilic lenses have been introduced in the market. We investigated LEC proliferation on 6 models of hydrophilic lenses.

PATIENTS AND METHODS

One hundred twenty-six eyes scheduled for cataract surgery were enrolled in this prospective comparative study. Exclusion criteria were proliferative diabetic retinopathy, uncontrolled glaucoma, corneal pathology, and previous intraocular surgery. Patients with a history of uveitis or antiinflammatory medication use within 14 days before surgery were also excluded from the study.
The following IOLs were examined: Visionflex A-100 (Distra Softcryl, 1 piece, modified C-loop, sharp optic edge; n = 20), Rayner Centerflex 570H (1 piece, plate haptic, sharp optic edge; n = 29), Collamer CC4204BF-IOL (Staar, 1 piece, plate haptic, sharp optic edge; n = 30), Injectacryl F 3000 (Distra GmbH, 3 piece, sharp optic edge; n = 26), Hydroview H60M (Bausch & Lomb, 3 piece, round optic edge; n = 29), and MemoryLens (ORC, 3 piece, round optic edge; n = 29) (Table 1).

All surgery was performed by an experienced surgeon (M.A., A.K., J.S.) using peribulbar anesthesia. A standardized operation technique was used: a temporal 3.2 mm clear corneal incision, and continuous curvilinear capsulorhexis under sodium hyaluroilate 1% (Healon), followed by hydrodissection, hydrodelineation, and phacoemulsification. The IOLs were implanted in the bag. The capsulorhexis had a diameter of about 4.5 to 5.0 mm. Only eyes with a completely overlapping continuous anterior capsulorhexis rim of the capsule were included in the study.

The first postoperative night, all patients received an ointment dressing of betamethasone–neomycin eye ointment (Dexagenta POS). The following IOLs were examined with a slitlamp (Haag-Streit) on the first postoperative day and 1 week, 1, 3, 6 months, and 1 year after implantation, and the data were registered according to a standardized protocol. For the purpose of evaluation, the capsule-free IOL surface was divided into quadrants and each quadrant was assessed semiquantitatively as follows: grade 0 = no LECs; grade 1 = some LECs growing on the IOL; grade 2 = a loose layer of LECs; grade 3 = a dense cell layer on the anterior lens surface. The product with the highest density and the number of quadrants with this density were used for statistical calculation.

Variables are described by means and percentages. For statistical analysis, all pairwise comparisons were performed using the Mann-Whitney U test. A P value less than 0.05 was considered statistically significant. The SPSS 10.0 System for Windows was used for statistical calculation.

RESULTS

At every time of investigation, the Hydroview and Visionflex IOL showed the greatest ongrowth of LECs compared with all other IOLs. The maximum ongrowth was registered on day 30. At this time, 100% of the Hydroview IOLs and 93% of the Visionflex IOLs had LECs on the capsule-free anterior IOL surface (Figure 1). From postoperative day 7 on and at every subsequent time point, this difference was statistically significant compared with all other IOLs (P<.028). At days 7 and 30, there was a significant difference between these 2 IOLs as well (day 7, P < .001; day 30, P = .019) (Figure 2).

After 1 month, LECs were found on 76% of all MemoryLens IOLs. The most pronounced ongrowth of LECs was also registered at this time (Figure 1). This was significantly less than the ongrowth on the Hydroview and Visionflex IOLs (P < .001) and significantly greater than the ongrowth on the Collamer, Rayner, and Injectacryl IOLs (P < .001). After this time, the density of LECs was continuously reduced until the last time of investigation, but still remained statistically significant compared with all other IOLs (P < .007) with the exception of the Collamer IOL 1 year postoperatively (P = .361).

At every time of observation, the Collamer, Rayner, and Injectacryl IOLs showed minimal ongrowth of LECs on the anterior IOL surface (Figures 1 and 2). On postoperative day 7, a statistically significant difference was registered between the Collamer and the Injectacryl IOLs (P < .023); at no point in time was there any statistically significant difference among these 3 IOLs. On postoperative day 7, the largest number of IOLs with LECs was seen in the Injectacryl group (19%) compared with the other 2 lenses; however, the cell density was low.

At none of the investigations was a statistically significant difference registered between the Collamer and the Rayner IOLs (P > .062) or between the Rayner and the Injectacryl IOLs (P > .146).

DISCUSSION

After in-the-bag implantation of an IOL, direct contact between the lens and the LECs causes cytokines to be released. This is followed by proliferation and myofibroblastic metaplasia of the LECs. The most severe complication is

Table 1. Characteristics of the IOLs.

<table>
<thead>
<tr>
<th>IOL</th>
<th>Optic Material</th>
<th>Water Content (%)</th>
<th>Edge Design</th>
<th>Optic/IOL Diameter (mm)</th>
<th>Haptic Material/Design</th>
<th>Haptic Angulation (Degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroview</td>
<td>PolyHEMA/HOHEXMA</td>
<td>18</td>
<td>Round</td>
<td>6.0/12.5</td>
<td>PMMA</td>
<td>10</td>
</tr>
<tr>
<td>Visionflex</td>
<td>HEMA-EOEMA</td>
<td>25</td>
<td>Sharp</td>
<td>6.0/12.5</td>
<td>Single piece</td>
<td>0</td>
</tr>
<tr>
<td>Injectacryl</td>
<td>2-HEMA/MMMA</td>
<td>26</td>
<td>Sharp</td>
<td>6.0/12.5</td>
<td>PVDF</td>
<td>5</td>
</tr>
<tr>
<td>Rayner</td>
<td>PMMA/polyHEMA/EGDMA</td>
<td>26</td>
<td>Sharp</td>
<td>5.75/12.0</td>
<td>Single piece</td>
<td>0</td>
</tr>
<tr>
<td>Collamer</td>
<td>Collagen/polyHEMA</td>
<td>33</td>
<td>Sharp</td>
<td>6.0/10.8</td>
<td>Single piece</td>
<td>0</td>
</tr>
<tr>
<td>Memory</td>
<td>HEMA/MMMA</td>
<td>20</td>
<td>Round</td>
<td>6.0/13.0</td>
<td>Poly</td>
<td>10</td>
</tr>
</tbody>
</table>

Collagen = 0.3% porcine collagen; EGDMA = ethylene glycol dimethacrylate; EOEMA = 2-ethoxethyl methacrylate; HEMA = 2-hydroxethyl methacrylate; HOHEXEMA = 6-hydroxethyl methacrylate; MMA = methyl methacrylate; PMMA = poly (methyl methacrylate); Poly = polypropylene; polyHEMA = poly 2-hydroxethyl methacrylate; PVDF = polyvinylidene fluoride
opacification of the posterior capsule, which may lead to an enduring deterioration of visual acuity.

In contrast, anterior capsule opacification and the ongrowth of LECs on the anterior surface of the lens rarely cause a visual impairment. However, severe anterior capsule opacification in combination with capsule phimosis may lead to impaired vision and also limit the examination and treatment of the peripheral retina.

Attempts to reduce this ongrowth of LECs by surgery proved to be impracticable and failed to produce the desired results.9–11 Until now, inhibition of LEC proliferation by means of medication was also unsuccessful. Substances such as heparin or minoxidil in the rinsing solution led to a milder postoperative inflammatory reaction, but inhibition or reduction of the cellular reaction was not achieved.12–14

Several studies conducted in the past few years show that the implantation of an IOL with a sharp-edged optic reduces the development of posterior capsule opacification.15–17 The sharp edge serves as a barrier to the ongrowth of LECs on the posterior capsule and reduces the development of posterior capsule opacification. However, the edge design has no influence on the ongrowth of LECs on the anterior IOL surface.7 This was confirmed in our study. The sharp-edged Visionflex IOL had the maximum ongrowth of LECs, exceeding the ongrowth on the round-edged Hydroview or Memory IOLs.

The lens design also had no impact on LECs. The single-piece Rayner and Collamer IOLs were associated with an equally low incidence of LECs as the 3-piece Injectacryl and MemoryLens IOLs. The single-piece Visionflex IOL and the 3-piece Hydroview IOL were both associated with a high incidence of LECs.

Haptic angulation also had no impact on the ongrowth of LECs on the IOL anterior surface. The Visionflex IOL without haptic angulation showed as high an incidence of LECs as the Hydroview IOL with an angulation of 10 degrees. The Injectacryl and MemoryLens IOLs with a haptic angulation of 5 or 10 degrees were associated with a low incidence of LECs as the Collamer and Rayner IOLs without haptic angulation.

According to articles published by Linnola et al.18–21 and Saika and coauthors,6 different IOL materials have different protein layers. Fibronectin binds more to hydrophobic IOLs; collagen type IV binds more to hydrophilic IOLs. They are supposed to play an important role in LEC ongrowth and its development, such as remission and myofibroblastic transformation.

Despite the common trend toward LEC ongrowth in specific lens groups, singular IOLs in these groups showed no ongrowth. This suggests that the development of LEC ongrowth is not only dependent on IOL characteristics alone, but also on until-now-unknown, patient-dependent parameters. Further studies are necessary to evaluate these parameters.

The water content also had no influence on LEC ongrowth. The Hydroview IOL, with a water content of 18%, had the greatest LEC density compared with the other lenses. The Rayner, Collamer, and Injectacryl IOLs, with a water content of 26% or more, had a relatively low LEC density. However, the Visionflex IOL had the highest LEC density, despite a water content of 25%.

In conclusion, our study shows that hydrophilic IOLs, which have been developed and improved over the past few years, are characterized by significantly less ongrowth of LECs on the anterior IOL surface. These changes approach the results of hydrophobic IOLs and therefore show a conspicuous improvement in capsule biocompatibility. Our findings also confirm that it is mainly the material, and not the lens or edge design, that plays a decisive role in ongrowth and density of LECs on the anterior lens surface and that the individual types of hydrophilic IOLs have different patterns of reaction.
depending on the material and other until-now-unknown parameters.

REFERENCES