IOL’s Opacification: A Complex Analysis Based on the Clinical Aspects, Biomaterials Used and Surface Characterization of Explanted IOL’s

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IOL opacification is a growing issue reported lately in the specialty literature. [1-5] This article follows a series of retrospective cases regarding hydrophobic IOLs that were explanted from three different patients. The explants were examined using AFM and SEM (with EDS), in order to find more details about the surface morphology and the composition of the deposits. The results indicate that they are composed mainly of calcium and phosphate. The authors suggest that ocular comorbidity and other systemic factors are contributing to this complication.

Keywords: IOL opacification, explanted IOL, surface deposits

An intraocular lens implant (IOL) is a synthetic, artificial lens placed inside the eye that replaces the focusing power of a natural lens that is surgically removed, usually as part of cataract surgery. There are two types of IOLs: pseudophakic (IOL) and phakic intraocular lens (PIOL). The pseudophakic IOL is the most common type, and are implanted during cataract surgery, after the cloudy crystalline lens (cataract) has been removed. The phakic intraocular lens (PIOL) is a lens that is placed over the existing natural lens, and is used in refractive surgery to change the eye optical power as a treatment for myopia. IOLs usually consist of a small plastic lens with plastic side struts, called haptics, to hold the lens in place within the capsular bag inside the eye.

IOLs were traditionally made of an inflexible material (PMMA), although this has largely been superseded by the use of flexible materials. Most IOLs fitted today are fixed monofocal lenses matched to distance vision. However, other types are available, such as multifocal IOLs that provide the patient with multiple-focused vision at far and reading distance, and adaptive IOLs, which provide the patient with limited visual accommodation.

The ideal IOL should offer easiness of implantation, lack of intraoperative complications, good and long-lasting vision, and refractive stability.

Recently, a tendency has developed preferring foldable IOLs and especially those suitable for micro incision cataract surgery (MICS), i.e. those IOLs that can be implanted through sub-2 mm incision. These lenses are usually hydrophilic acrylic single-piece IOLs. IOL materials are defined hydrophobic or hydrophilic according to the angle a drop of water makes with respect to the material surface. The more acute this angle is, the more hydrophilic the material is defined. Hydrophilic IOLs are very popular in Europe because of the easy handling, the sub-2-mm implantation, the low risk for capsular bag damage during implantation, and the improving results with posterior capsular opacification (PCO).

The several types of IOLs currently available can be differentiated in several ways, the most important of which are shown in the table 1.

Post operative opacification of intraocular lenses (IOLs) has been reported in a variety of clinical settings and with various IOL types and materials available [1-4,6,7].

Depending on the underlying process, IOLs can become opacified or discolored at any time during or after surgery. Intraoperative and postoperative medications, such as topical steroids and beta-blockers, and those containing phosphorous compounds, such as some glaucoma medications, have been hypothesized to promote this phenomenon [7]. IOL opacification is a major cause of

<table>
<thead>
<tr>
<th>Destination</th>
<th>Capsular bag, ciliary sulcus, scleral fixation, iris fixation, angle supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall design</td>
<td>3 piece/1 piece</td>
</tr>
<tr>
<td>Overall length</td>
<td>10–13 mm</td>
</tr>
<tr>
<td>Optics material</td>
<td>Rigid (PMMA), flexible (silicone), foldable (hydrophobic acrylic) hydrophilic acrylic, Collamer</td>
</tr>
<tr>
<td>Refraction index</td>
<td>1.42–1.55</td>
</tr>
<tr>
<td>Optics shape</td>
<td>shape Biconvex, plano-convex, meniscus</td>
</tr>
<tr>
<td>Optics diameter</td>
<td>5–7 mm</td>
</tr>
<tr>
<td>Optics design</td>
<td>Spherical, aspheric, toric multifocal, multifocal toric</td>
</tr>
<tr>
<td>Optics color</td>
<td>Transparent, tinted</td>
</tr>
<tr>
<td>Haptics properties</td>
<td>properties 3 piece/1 piece (PMMA, PVDF, polyamide, 2, 3, 4, 6 haptics)</td>
</tr>
<tr>
<td>Type of implantation</td>
<td>Injectable, not injectable</td>
</tr>
<tr>
<td>Type of packaging</td>
<td>Pre-loaded, not pre-loaded</td>
</tr>
</tbody>
</table>

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Table 1
CLASSIFICATION OF IOLs

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The second patient was a 59-year-old female with severe non-proliferative diabetic and hypertensive retinopathy who was submitted during September 2010 in a fellow medical facility and underwent phacoemulsification with uneventful implantation of a posterior chamber IOL in the right eye. From the medical records resulted that there were no intraoperative complications. At the moment of the surgery, the patient had hard exudates in the macula and few microaneurysms in the right eye. In the left eye, she had mild nuclear and cortical sclerosis. Pan-retinal photocoagulation and an intravitreal injection of triamcinolone acetonide and Avastin were done in both eyes three and two years prior to cataract surgery. One month after phacoemulsification, she presented at our facility with hard exudates in the macula and clinically significant macular edema. She was submitted for triamcinolone acetonide and Avastin and grid photocoagulation one month later. Her uncorrected vision after the laser was Snellen 0.4. Twenty-six months after surgery, her uncorrected visual acuity in the right eye was Snellen 0.2. She had no macular edema or macular exudates. Thirty months postoperatively she presented with an uncorrected vision on the right eye of Snellen 0.1. On biomicroscopy IOL and opacification was noted. The IOL was explanted two months later. A posterior vitrectomy was also performed. A hydrophobic acrylic IOL was implanted in the ciliary sulcus. Two months after IOL exchange, the BCVA in the right eye was Snellen 0.4.

The last patient was a 62-year-old woman with a hydrophobic acrylic IOL and without a prior history (except for the cataract surgery) presented 26 months postoperatively with a rhegmatogenous retinal detachment. She underwent 25-gauge pars plana vitrectomy using perfluoro-n-octane (PFO), air-fluid exchange and C3F8 gas tamponade. One week after surgery, a non-buoyant fluid bubble thought to be PFO was noted to fill 2 to 5 % of the postremal chamber. Posterior 25-gauge pars plana vitrectomy was performed on postoperative week 4 to remove the retained PFO. Anterior segment examination at one month postoperative revealed numerous small, white, optic opacities in the IOL and no PFO bubble at fundus examination. The lenticular opacities were unchanged at postoperative month 3 and 6 and no residual PFO was noted in the postremal chamber. The IOL was explanted three months later and a hydrophobic acrylic IOL was implanted in the ciliary sulcus.

Results and discussions

Gross examination of the explanted IOLs showed a whitish discoloration of the specimens. Light microscopy examination showed dense deposits forming an almost a continuous crust, on both surfaces of the optic component. The results of scanning electron microscopy investigations are shown in the next figures. Because the same aspects were revealed in each clinical case, just the relevant results for our experimental part will be presented.

![Fig. 1. Slit-lamp view of the anterior segment of the eye showing intraocular lens (IOL) opacification](http://www.revmaterealeplastice.ro)
As we could see in figure 1, multiple and small granular deposits were generally observed within the optic and haptics of the lenses, close to the surface. Also, some peripheral areas of the optic were relatively clear of surface and substance deposits/granules.

When we analyze the optic surface of the lenses, we found regular microgranular features and infrequent ridge-like structures over almost entire optic surface of the lenses. The analysis of the small area of this surface who was made using AFM show in evidence the different dimension of the deposits but also we could conclude that on surface are different nanoparticles from different origin.

In order to find the nature of the micro granular features and infrequent ridge-like structures that were observed over almost the entire optic surface of the lenses, we performed an energy dispersive X-ray (EDS) analyses on the deposits. The experimental results, shown in figure 5, demonstrated the presence of peaks of calcium and phosphorus.

Calcification of the intraocular lenses seems to have a multifactorial origin. The formation of calcium deposits seems to depend both on the material of the IOL and on the local chemical microenvironment of the aqueous humor. The etiology of such calcification has not yet been fully understood and may be related to the manufacturing process and even to diseases the patient has. However, other processes may be involved in IOLs made of different materials, such as excessive inflow of water in hydrophobic materials, direct discoloration caused by dyes or medications, and even slow and progressive degradation of the biomaterial [9]. There may be a possible association between IOL calcification and the metabolic disturbances in diabetes [4,6] as the level of phosphorus in the aqueous humor of diabetic patients, particularly those with proliferative diabetic retinopathy, is significantly higher than normal individuals.

Conclusions
IOL calcification is a sight-threatening complication of lens implantation. When comparing the visual acuity before and after IOL opacification, we noticed that all patients lost more than three Snellen lines in visual acuity.

The crystalline deposition on IOLs can be divided into two general time frames: intraoperative or shortly postoperative versus late postoperative. Our patients had all late postoperative IOL calcification. This means that although the mechanism of this complication is not fully understood, it does not seem to be directly related to substances used during the surgery as it occurred in the late postoperative period. In the first case presented, only one of the lenses exhibited calcification. Both surgical implantations were performed within 1 month by the same surgeon, using the same IOLs. This may suggest that local conditions of supersaturation, either in the vicinity of the surface of the IOLs or within their substance, may promote salts development by diffusion of calcium/phosphate ions, as suggested by other studies too [10].

Not all patients with IOL calcification have underlying systemic diseases [10] – thus the material related association might be another likely explanation. The only effective treatment to restore vision is explantation and
exchange of the calcified IOL. There were no intraoperative complications in all of our cases.

References

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