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CASE REPORT

Postoperative diffuse opacification of a hydrophilic acrylic intraocular lens: analysis of an explant

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Abstract
Purpose We describe the clinicopathological and ultrastructural features of an opaque single-piece hydrophilic acrylic intraocular lens (IOL) explanted from a patient.
Method The main outcome of this report is the documentation of calcium deposits confirmed by surface analysis. The decrease in visual acuity was due to the opacification of the IOL. The opacification involved both the optic plate and the haptics.
Results The analysis at the scansion electron microscope revealed that the opacity was caused by the deposition of calcium and phosphate within the lens optic and haptics.
Conclusion This is the first case about the opacification of an Oculentis L-313. The opacification was characterized by calcium and phosphate deposition probably due to a morphological alteration of the posterior surface of the IOL.

Keywords IOL · Opacification · Hydrophilic acrylic intraocular lens

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Introduction

Small-incision cataract surgery, with implantation of foldable lenses, has evolved significantly over the past two decades. Currently, foldable intraocular lens (IOL) biomaterials include silicone, hydrophobic acrylic, and hydrophilic acrylic (or hydrogel materials) [1, 2].

Hydrophilic acrylic IOL are generally manufactured from poly hydroxyethyl methacrylate (or poly HEMA) and other hydrophilic acrylic copolymers. Several studies showed that these IOLs are very biocompatible and resistant, also to yttrium–aluminum–garnet laser damage [3, 4].

However, several reports of unacceptable opacification of the modern hydrophilic acrylic foldable IOL designs have raised concerns regarding their long-term biocompatibility [5, 6].

A review of the literature of the last 15 years revealed that since 1999, optic opacification of some hydrophilic acrylic IOLs has been a significant complication leading to IOL explantation. In the USA, the IOL models involved in this problem are the Hydroview (Bausch & Lomb), the MemoryLens (Ciba Vision), the SC60B-OUV (Medical Developmental Research), and the Aqua-Sense (Ophthalmic Innovations International). The opacification was found on the optic surfaces of the Hydroview and the MemoryLens and within the substances of the SC60B-OUV and the Aqua-Sense. Histochemical and surface analytical analysis showed that the composition of

opacification was made of calcium and phosphate deposits [7].

We observed a case of the opacification of a hydrophilic acrylic IOL (Lentis L-313, Oculentis GmbH, Berlin, Germany). To our knowledge, this is the first case of late opacification of this IOL model.

Case report

In 2010, a 62-year-old man referred to the Institute of Ophthalmology of University of Modena (Italy) to undergo cataract surgery in both eyes. At the time of surgery, the patient was in excellent health without any systemic or ocular comorbidity.

Phacoemulsification and implantation of a single-piece hydrophilic acrylic IOL in the capsular bag was performed by the same surgeon in both the eyes, without any intra- or postoperative complication. Phacoemulsification was performed by the bimanual microincision cataract surgery technique (BMICS) [8, 9].

A Lentis L-313 IOL (Oculentis GmbH, Berlin, Germany) was implanted in the right eye and a BunnyLens AF (Hanita Lenses, Israel) in the left eye.

Postoperative best corrected visual acuity (BCVA) was excellent in both eyes (0 LogMAR, 10/10).

After 2 years, an initial opacification of the Lentis L-313 IOL was noted at the ophthalmological examination without any reduction in visual acuity. The opacification seemed to involve only the posterior surface with a cloudy aspect that was similar to an initial posterior capsule opacification.

On the contrary, no signs of opacity were found on the BunnyLens AF implanted in the left eye.

After 5 years, the patient referred to our institute complaining about decreased visual acuity (BCVA 0.5 LogMAR, 3/10) in the right eye, with an excellent visual acuity in the left one (0 LogMar, 10/10). After a consistent degree of mydriasis, the IOL was observed at the slit lamp microscope and it appeared to be completely opaque. The opacification involved both the optic plate and the observable portions of the haptics. The only visible macroscopic alteration was a little cloudy circle at the center of the optic plate of the IOL. The IOL in the left eye was completely transparent (Fig. 1).

The anterior segment optical coherence tomography (AS-OCT) analysis showed a hyper-reflectance of the anterior and posterior surfaces of the optic plate of the IOL. A circular irregularity of the posterior surface of the IOL was noticed.

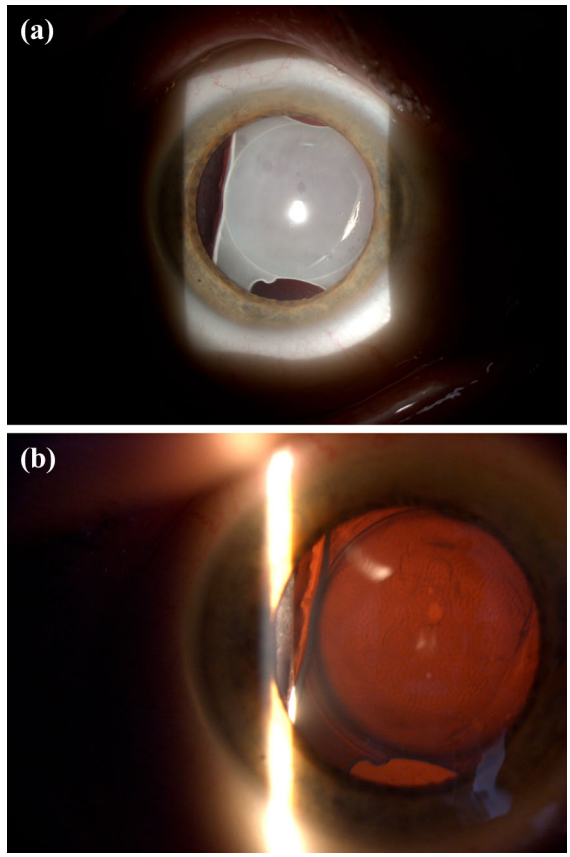

Fig. 1 **a** Slit lamp view of the opaque IOL. **b** The same IOL in retroillumination view. The arrow shows a little cloudy bubble in the middle of the optic plate

This irregularity involved the center of the posterior surface, and it was characterized by a low internal reflectance with high reflectance of the borders. The internal structure of the IOL appeared to be transparent at the AS-OCT analysis with no signs of abnormal reflectance (Fig. 2).

The IOL was explanted. Two 1.4-mm clear corneal incisions (CCI) were performed to move the IOL from the capsular bag toward the anterior chamber by means of a spatula, a lens-hook, and an ophthalmic viscosurgical device (OVD). No signs of fibrosis of the capsular bag were found, and the IOL was easily moved on a plane anterior to the iris. The IOL was then divided into two pieces by a microforceps. After enlarging on of the CCIs, the two halves of the lens were removed, and a single-piece hydrophobic IOL

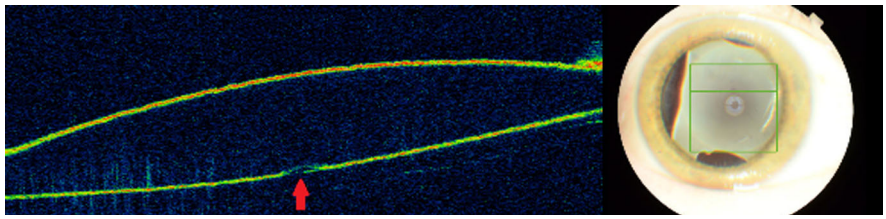

Fig. 2 AS-OCT image of the IOL. The *arrow* shows the circular irregularity on the posterior surface of the IOL

(Tecnis ZCB00, Abbott Medical Optics Inc., Santa Ana, USA) was implanted in the bag. After being removed from the eye, the IOL was placed in a sterile vial containing balanced salt solution (BSS) and sent to the laboratory for the microscopic and molecular analysis. Care was taken to avoid any manipulation of the IOL optics with forceps or other grasping instruments. Gross macroscopic analysis was performed, and gross photographs were taken. The cut sections of the IOL were air-dried at room temperature for 7 days, coated with gold, and examined under scanning electron microscope (SEM). SEM photomicrographs and energy-dispersive radiograph spectrum from the cut sections of the optic of the explanted IOL were taken.

At a magnification of 32×, the SEM analysis showed a diffuse irregularity of the surface of the IOL, involving both the optic plate and the haptic portion. The same circular irregularity was noticed on the posterior surface of the optic plate. At a magnification of 200×, fine deposits were observed on the whole surface of the IOL. The same deposits were noticed on the cut margin of the IOL.

We decided to observe these fine deposits at a 800× magnification. They were little sphere shaped and with a uniform distribution (Figs. 3, 4, 5).

The energy-dispersive radiograph spectrum showed the presence of calcium (Ca) and phosphate (P); within they had deposits of the IOL (Fig. 6).

The SEM analysis of the cloudy circle at the center of the optic plate revealed a smooth surface with no visible deposits if compared with other portion of the optic surface. Moreover, the energy-dispersive radiograph spectrum showed no evidence of Ca and P deposition (Fig. 7).

The explant and exchange procedures were carried out without complications. The BCVA at the latest follow-up was 0 LogMar (10/10).

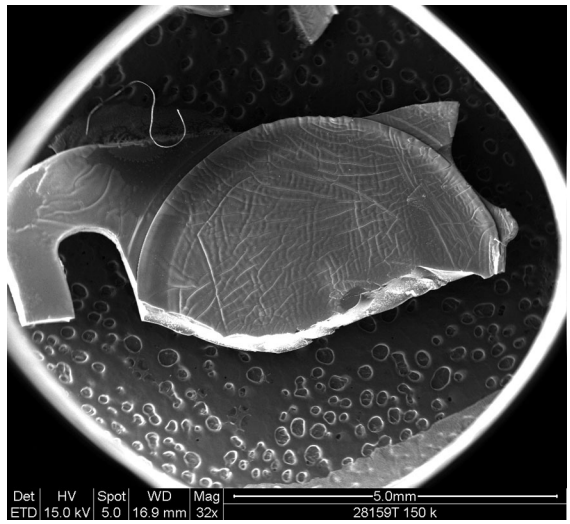

Fig. 3 A cut section of the explanted IOL at the SEM analysis a 32× magnification

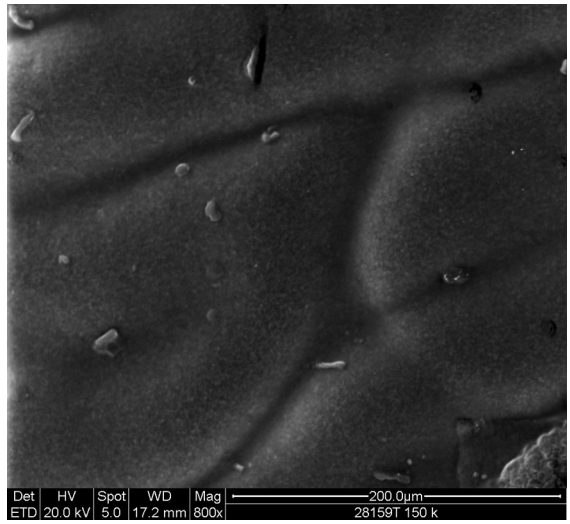

Fig. 4 A detail of the IOL surface with fine circular deposits

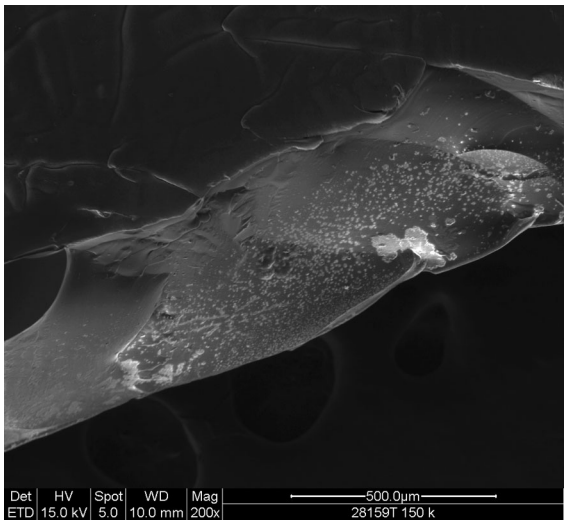

Fig. 5 A detail of the IOL thickness with fine circular deposits

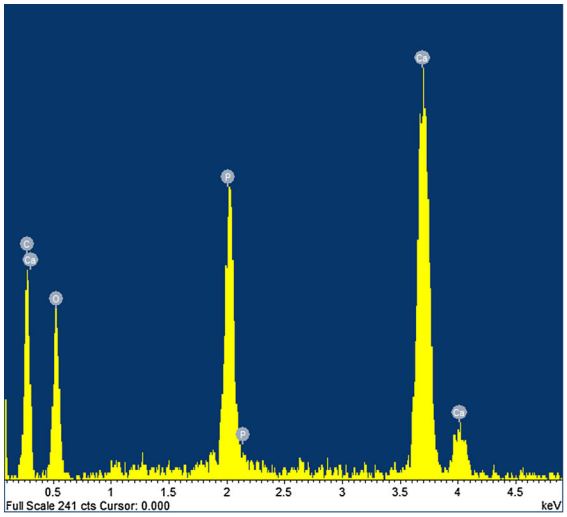

Fig. 6 Energy-dispersive radiograph spectrum from the deposits shows calcium (ca) and phosphate (P) peaks. *O* oxygen, *C* carbon

Discussion

In this report, the first case of opacification and explantation of a Lentis L-313 IOL is described.

In literature, the main causes for IOL explantation are dislocation or decentration, followed by incorrect IOL power and IOL opacification. IOL opacification is a rare postoperative late complication. It has been attributed to surgical technique, specific defects in IOL manufacturing, patient's associated ocular and systemic comorbidities, or a combination of these factors. It has been observed with several materials, especially for hydrophilic ones. Hydrophilic acrylic IOLs are more flexible of hydrophobic IOL thanks to a greater water content that makes them flexible, permitting their use in microincision cataract surgery, such as in this case [10].

The explantation of acrylic hydrophilic IOLs due to postoperative late opacification has been reported in several cases, and some of the most common explanted hydrophilic acrylic IOLs include Hydroview, MemoryLens, SC60B-OUV and the AquaSense. In addition, two cases of postoperative opacification after implantation of Centerflex 570H (Rayner, East Sussex, UK) and a case of Akreos Adapt AO (Bausch & Lomb) have been described [11–13].

Continuous technological innovations in IOL manufacturing have minimized the incidence of hydrophilic IOL opacification. In fact, IOLs that combines a hydrophilic acrylic core and hydrophobic coating have been recently introduced to maximize the best properties of both materials, minimizing the complications inherent to hydrophilic acrylic IOLs [14].

However, Bompostor-Ramos et al. described a cluster of IOL opacification with the Lentis LS-502-1 (Oculentis GmbH) which is made of a "Hydrosmart" hydrophilic biomaterials with a high water content and a hydrophobic surface. The opacification was due to calcium deposition showing that hydrophilic IOL with hydrophobic surface is not immune to opacification [10].

Several hypotheses have been proposed, but the real physiopathological mechanism that lead to the spontaneous opacification of an IOL remains unclear.

In literature, the blood–aqueous barrier breakdown has been considered one of the possible causes of opacification [15].

In fact, complicated surgery or both ocular pathologies and systemic diseases (e.g., diabetes) could determine this condition.

There is an important correlation between blood–aqueous barrier breakdown, inflammation and possible cause of IOL opacification. Hollick et al. found a different rate of lens epithelial cells (LECs) proliferation in patient implanted with hydrogel lens with no significant difference in the preoperative flare and cell values, age, sex, iris color and cataract type. Those patient with a significant lower postoperative inflammation (less flare, less cells), representing less postoperative blood–aqueous barrier breakdown, had less

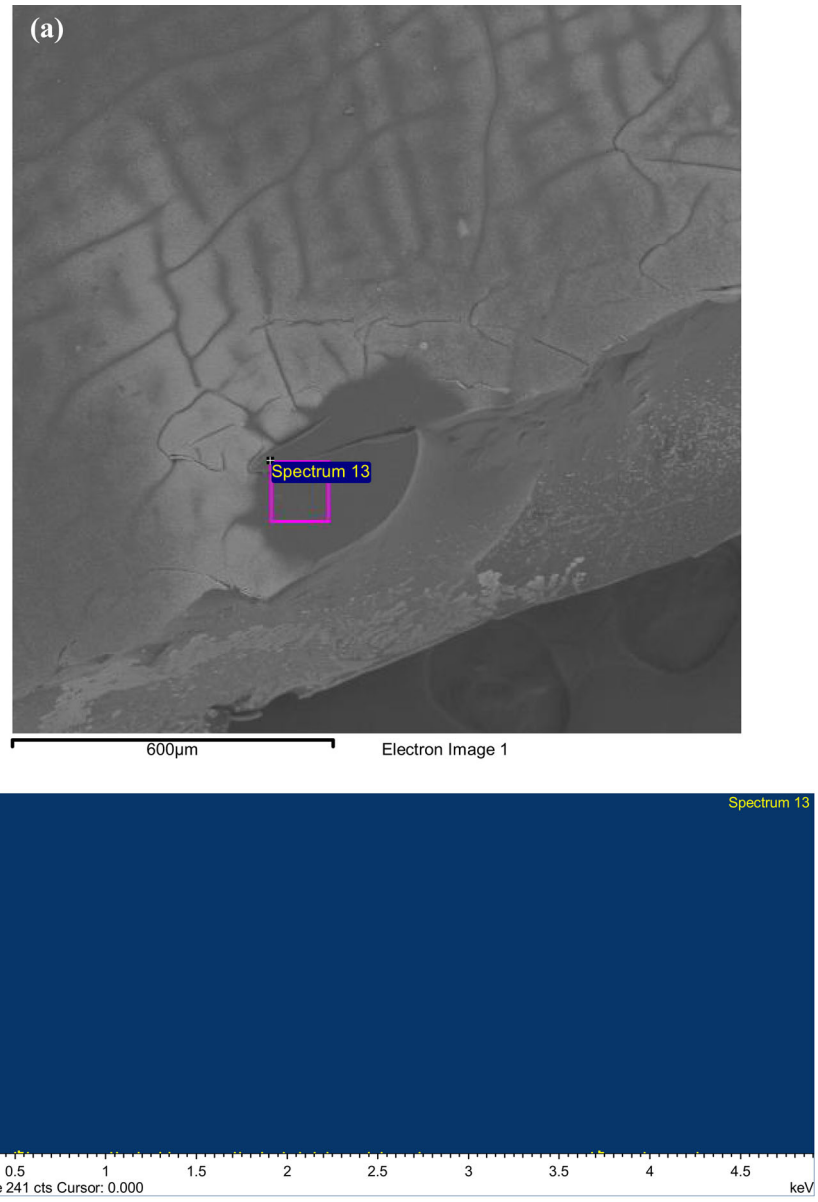

Fig. 7 **a** A detail of the cloudy circle at the center of the optic plate. **b** Energy-dispersive radiograph spectrum from the cloudy circle showed no evidence of deposition

LECs on the anterior surface of the IOL than those patients with higher postoperative inflammation and more LECs after surgery.

As our patient had no ocular or systemic disease, uncomplicated cataract extraction was performed and no other eye surgeries were taken, the opacification of this IOL could be linked to a high inflammation level occurred in the postoperative period and maybe the LECs could represent a scaffold for calcium crystal deposition on the IOL surface [4, 16, 17].

A case of IOL opacification with an irregularity of the substance of the lens and not of the external surface was described by Hunter et al. Their analyses revealed that the deposits causing the opacification were distributed within a void around an optic bridge found during the microscopic examination [18].

Differently, the defect described in this report involved mainly the surface. The origin of the optic defect remains unclear. It is unlikely that this could have happened during the manufacturing of the lens or

during intraoperative manipulation, because it was noticed 5 years post-op. Moreover, the absence of postoperative inflammation makes difficult the association between the IOL opacification and ocular pathology.

The small round bubble on the posterior surface of the optic plate may cause an alteration of the normal architecture of the IOL that probably lead to calcium and phosphate deposition.

The exact mechanism leading to the formation of optic circle and to the mineral deposition requires further investigation.

The manufacturer published a field safety note in which they probably attributed the opacification to the system of packaging. Generally, the opacification rate of 0.011% (only for lenses in glass vials) is within an acceptable level of possible complications which can occur with implantations of hydrophilic IOL. Since 2012, the manufacturer changes the glass vial with a new blister packaging. For this reason, it is important to mention the classification of postoperative IOL calcification proposed by Neuhann et al. in primary, secondary and false-positive calcifications. Primary calcification is related to or caused by the IOL itself, and it is due to polymer formulation or manufacturing or packaging problems. Secondary calcification refers to calcium deposition onto the IOL surface resulting from environmental circumstances independent of the IOL itself such as associated systemic or ocular diseases, complex surgery with rupture of the blood–aqueous barrier. False-positive calcification or pseudocalcification refers to cases in which misdiagnosis may occur because of tissue artifacts and incorrect use of special stains [19].

According to this classification, it is difficult to include our case in the primary or secondary calcification group. Since that it is difficult to determine with certainty a manufacturing IOL problem, it is reasonable to include this report in secondary calcification group be aware of no ocular or systemic comorbidities were present at the time of surgery and maybe linked to a high postoperative inflammation that could cause the alteration of IOL surface and the consequent opacification. On the contrary, according to the manufacturer this case is probably one lens packed with the old glass vials.

At this point, it could be useful to investigate whether the opacification was really caused by the packaging or by an alteration of the substance and surface of the IOL.

In conclusion, the cause of this dystrophic calcification remains unknown and further studies should be undertaken to evaluate the underlying mechanism of the delayed postoperative opacification of hydrophilic acrylic IOL.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical standards All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments are comparable ethical standards.

Human and animal rights statements This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

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