

A Late Complication of Polymethyl Methacrylate (PMMA) Intraocular Lens- an Unusual Degeneration

LZ Heng¹, I Fearnley², Ramin Khoramnia³, Tamer Tandogan³, Chul Young Choi³, Gerd U Auffarth³ and MP Snead^{1*}

¹Vitreoretinal Service, Addenbrooke's Hospital, Cambridge University Hospital NHS Trust, Hills Road, Cambridge CB2 0QQ

²Eye Department, Northampton General Hospital, UK

³David J Apple International Laboratory of Ophthalmic Pathology and International Vision Correction Research Centre (IVCRC), Department of Ophthalmology, University of Heidelberg, Heidelberg, Germany

*Corresponding author: Martin Snead MA MD FRCS FRCOphth, Vitreoretinal Service & Vitreoretinal Research Group, Cambridge University Hospitals NHS Foundation Trust, Hills Road, Cambridge CB2 0QQ Email: mps34@cam.ac.uk

Received date: June 25, 2015, Accepted date: July 28, 2015, Published date: Aug 03, 2015

Copyright: © 2015 Heng et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract

Polymethyl methacrylate (PMMA) was the material used in Sir Harold Ridley's original intraocular lens (IOL). Until the last decade, PMMA has enjoyed a reputation as a reliable and high quality optical material with very few complications associated with PMMA material alterations having been reported. Here, we report a clinical case of a 72 year old gentleman who presented with progressively increasing glare and decreased vision 20 years after his routine PMMA IOL implantation. The lens was explanted and sent for pathological analysis which revealed grey-brown 'bubble-like' lesions which were empty. Scanning electron microscopy showed cracks in the PMMA material which were correlated to decreased optical quality. The current findings are dissimilar from the known phenomenon of 'snow flake degeneration', which was the only reported late complication of PMMA lenses. This case report describes a new variant of an unexpected late complication associated with PMMA lenses.

Keywords: PMMA; IOL; Complication; Degeneration

Background

Polymethyl methacrylate (PMMA) was the material used in Sir Harold Ridley's original intraocular lens. Until the last decade, PMMA has enjoyed a reputation as a reliable and high quality optics material. Few complications associated with PMMA material alterations have been reported. Previously, Apple and Werner described 'snowflake degeneration' as a potential late complication of PMMA IOL implant and implied its pathogenesis to be associated with prolonged exposure to ultraviolet (UV) radiation [1].

The following case report describes a new pathological finding of a late complication associated with the PMMA lens.

Case Presentation

A 70 year old gentleman with a medical history of hypercholesterolemia presented with a 15 year history of worsening visual acuity and decreasing contrast sensitivity in his right eye.

The patient developed right radiation related cataract 27 years ago and underwent routine cataract removal via extra capsular cataract extraction (ECCE) and PMMA IOL (IOLAB) implantation in 1987. Twenty years after the surgery, he complained of decreasing night vision and occasional blurring of his right vision. His vision then was 6/6. Ophthalmic review by his community opticians described a 'frosty' pseudo-phakic intraocular lens and patient was referred for right Nd:YAG capsulotomy. Review by his local ophthalmologists noted "crystalline" deposits in the centre of the IOL and advised against Nd:YAG capsulotomy, as his vision was still good. Over the course of the next 5 years, the patient complained of a further

subjective deterioration of his vision and contrast sensitivity and his visual acuity on Snellen chart decreased from 6/6 to 6/18. He was then referred to Addenbrooke's vitreoretinal service for a second opinion for lens explantation.

Ophthalmic examination revealed crystalline deposits in the centre of the IOL. Intraocular pressure was within normal limits, anterior and posterior segment examination was otherwise unremarkable. His fellow eye had good vision and mild cataract. The patient underwent right IOL explantation with pars planar vitrectomy. Observations of the IOL during time of surgery found yellow-brown 'crystals' on the centre of the 3 piece PMMA lens. The explanted IOL was sent to the David J Apple International Laboratory for further evaluation and analysis.

Histopathological analysis

The explanted IOL was studied using gross and light microscopy in the dry state. Optical quality of the IOL was assessed using the OptiSpheric optical bench (Trioptics, Germany). The IOL was bisected; one half of the IOL was examined and photographed under an Olympus BX50 light microscope with an attached Olympus C-7070 camera (Olympus Optical Co. Ltd., Tokyo, Japan). This half of the IOL was stained (alizerin red and von Kossa) to determine the presence of deposits within the IOL.

The other half of the IOL was analysed using scanning electron microscopy (SEM). For the scanning electron microscopical examinations the IOL was prepared by ultramicrotomy (UCT, Leica, Germany) in order to obtain a very smooth cross section through the lens using a 35° diamond knife (Diatome, Switzerland). This cross section of the IOL was then examined by SEM under low kV

conditions using a SU8000 (Hitachi, Japan) without further coating of the sample.

Energy dispersive x-ray spectroscopy (EDS) was done using a Quantax 400 (Bruker, Germany) EDS detector attached to the SEM to detect any possible exogenous chemical elements within the IOL besides the PMMA material from which it was made.

Results

Gross and light microscopy revealed intralenticular lesions of crystalline-like appearance which were interpreted as foci of degenerated PMMA. The lesions were mainly located in the center of the optic (Figure 1a and 1b).

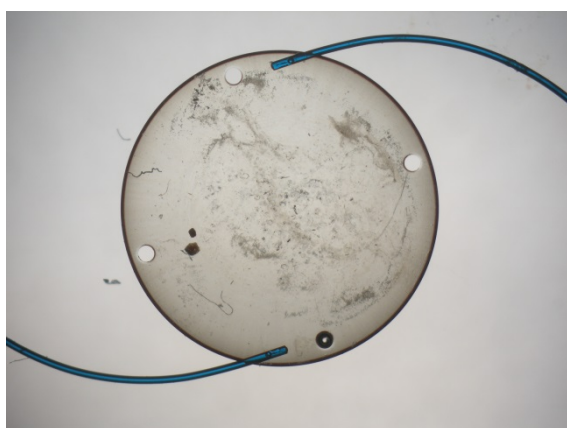


Figure 1a: Explanted 3 piece PMMA IOL with prolene haptics.

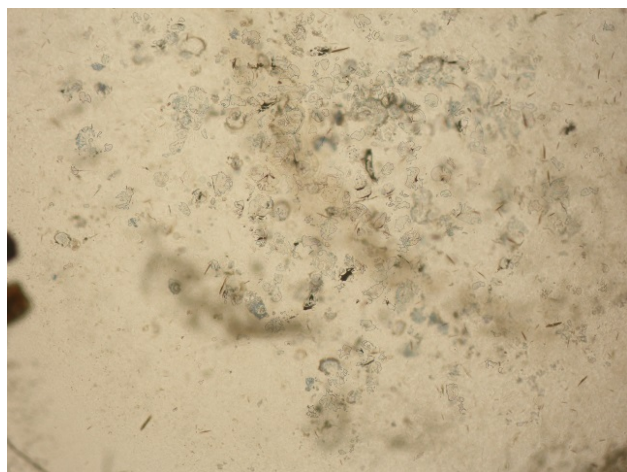


Figure 1b: Magnified view of clinically visible 'crystalline deposits' on IOL.

There was no evidence of "real" deposits within the IOL when examined with alizarin red and von Kossa stains.

Scanning electron microscopy (SEM) revealed no significant deposits on the IOL surface, but in cross-section revealed crack-like lesions within the substance of the optic (Figure 2). These lesions did not contain exogenous material. EDS measurements also did not show

any evidence for additional elements other than the ones present in PMMA itself (carbon and oxygen).

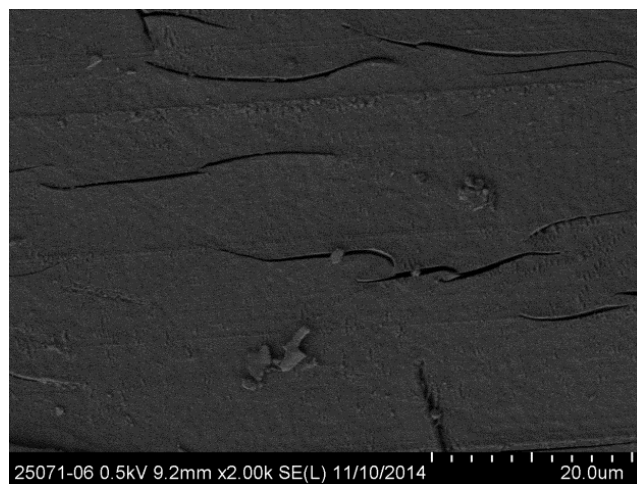


Figure 2: SEM images demonstrating 'cracks' in explanted IOL.

Analysis of the IOL at the optical bench showed a significant decrease in optical quality (Figure 3).

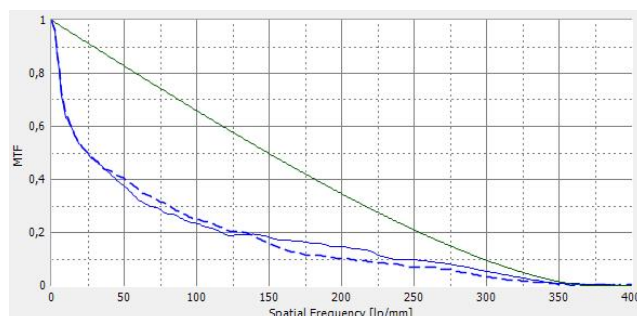


Figure 3: Decreased optical quality across measured IOL material. Green line: Diffraction limit representing the highest possible imaging quality of a given lens (theoretical limit). Blue dotted line: Measured values in sagittal plane. Blue continuous line: Measured values in tangential plane.

Differential diagnosis

Several differential diagnoses may be considered in this case. Posterior capsular opacity (PCO) is the most common mid to late term complication post cataract surgery. However, on slit-lamp examination there was no evidence of PCO and the opacities were 'crystalline' deposits lying deep within the IOL optic.

Calcification of hydrophilic acrylic lenses has been previously described [2-4]. however, no calcium deposits were found in the current sample.

The possibility of Snow flake Degeneration was also considered. However, in snow flake degeneration, the classical pathological description is of 'foci of degenerated PMMA biomaterial, typically consisting of an empty central space with fragmented PMMA

surrounded by dense outer “pseudocapsule”. The lesions are usually found within the anterior stratum of the IOL lens.[1] However, in this case, optically empty ‘cracks’ were found, associated with decreased optical quality.

Discussion

To date there have been few known long-term complications associated with PMMA IOLs. However, a few investigators have reported late post-operative (>10 years) complications, a phenomenon known as ‘snow flake degeneration’. Apple et al first described ‘snow flake degeneration’ in 2002 as a slowly progressive opacification of PMMA which under high magnification light microscopy appeared similar to ‘snowflakes’. Based on the pathologic observations which included first, aggregation of the opacities that were mainly confined to centre of the optics, with the peripheral rim free of opacification due to protection by the iris; and second, the appearance of highly intense lesions only in the anterior third of the IOL optic due to greater exposure of the lens to UV radiation, he hypothesised that prolonged exposure to ultraviolet radiation which may have initiated the progressive destruction of the PMMA IOL material. It has been suggested this may be related to the moulding process of PMMA lens in the 1980s and 1990s, which may have caused first, possible insufficient post annealing process of the cured PMMA polymer; or excessive thermal energy during curing process, resulting in voids in the PMMA matrix; or poor filtration of procured monomeric components (monomethyl methacrylate, UV blocker, thermal initiators) or excessive initiator substance during polymerization process. However, the exact mechanism of this phenomenon remains to be elucidated [1,5].

In the current report, cracks were noted through the surface of the IOL. Dahle et al, in a case report of a lens explanted with snowflake degeneration examined in the dry and hydrated states found multiple linear cracks in the hydrated state. Typical snowflake degeneration pathology was noted in the dry state. Based on their findings, the authors postulated that the clinical significance of snowflake degeneration was dependent on the amount of water collected within the cracks. In our study, the IOL was however, in the dry state [5].

Other than its use for intraocular lenses, PMMA has been used as cement in securing prosthetic joints in orthopaedic procedures. Several case series have reported the late failure of prostheses secondary to ageing of the PMMA cement, and ageing of PMMA as a material is a known phenomenon hypothesised to be associated with heat and water [6]. One explanation for the appearance of cracks in the IOL may be due to the breakdown of the polymerization of the monomers of the PMMA material over time [7].

Considering that the location of the deposits was similar to that of ‘snow flake degeneration’, the degenerative changes noted in this IOL explant may be related to UV light but the exact mechanism remains speculative. It is however unlikely to be associated with ageing of the PMMA materials noted in orthopaedic prostheses, because any event related to ageing is likely to have a higher rate of incidence than the currently isolated case report.

This is the first report of a new pathological description of PMMA lens degeneration. Although the clinical signs were similar to ‘snow flake degeneration’, the pathological analysis confirms a different aetiology. Cracks were seen within the PMMA biomaterial with a decrease in optical quality accounting for the patient’s symptoms. It is important to recognise the symptoms and signs of this late complication of PMMA IOL implant to prevent unnecessary intervention such as Nd:YAG capsulotomy, which would not be expected to resolve the patient’s symptoms and may increase the risk of, and compromise the options for, IOL exchange.

References

1. Apple DJ, Peng Q, Arthur SN, Werner L, Merritt J, et al. (2002) Snowflake degeneration of polymethyl methacrylate posterior chamber intraocular lens optic material: a newly described clinical condition caused by unexpected late opacification of polymethyl methacrylate. *Ophthalmology*, 109: 1666-1675.
2. Pandey SK, Werner L, Apple DJ, Kaskaloglu M (2002) Hydrophilic acrylic intraocular lens optic and haptics opacification in a diabetic patient: bilateral case report and clinicopathologic correlation. *Ophthalmology* 109: 2042-2051.
3. Fung SS, Sykakis, Islam NM, Zambarakji HJ, Khoramnia R, et al. (2015) Intraocular Lens Opacification following Intracameral Injection of Recombinant Tissue Plasminogen Activator to Treat Inflammatory Membranes after Cataract Surgery. *J Ophthalmol* 2015: 975075.
4. Khoramnia R, Salgado JP, Auffarth GU, Schmidt S, Wegner A, et al. (2012) [Opacification of a hydrophilic intraocular lens 4 years after cataract surgery. A biomaterial analysis]. *Ophthalmologie* 109: 483-486.
5. Dahle, Werner L, Fry L, Mamalis N (2006) Localized, central optic snowflake degeneration of a polymethyl methacrylate intraocular lens: clinical report with pathological correlation. *Archives of ophthalmology* 124: 1350-1353.
6. Ayre WN, Denyer SP, Evans SL (2014) Ageing and moisture uptake in polymethyl methacrylate (PMMA) bone cements. *J Mech Behav Biomed Mater* 32: 76-88.
7. McCrum NG, Buckley CP, Bucknall CB (1997) *Principles of Polymer Engineering*. Oxford University Press.