INVESTIGATION INTO THE CAUSES OF POST-OPERATIVE CALCIFICATION IN INTRAOCULAR LENSES

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1. INTRODUCTION

Hydrophilic acrylic polymers are routinely used in the manufacture of intraocular lenses for implant in patients suffering from cataracts. However, late post-operative complications caused by calcification[1] has recently been identified as a potential problem that results in visual impairment after the surgery

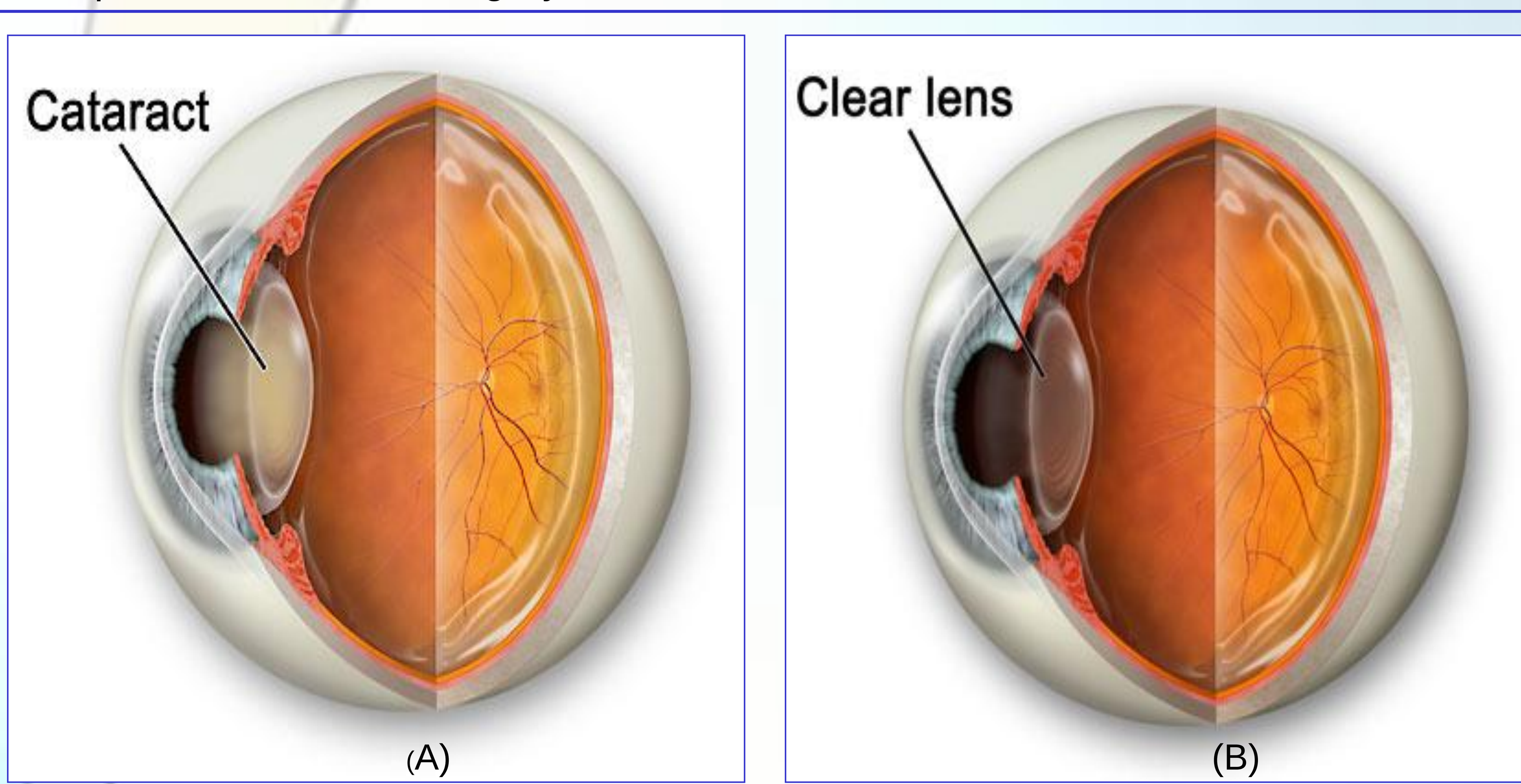


Fig 1:Diagram to show differences in the natural eye without cataract (A) and with cataract (B)

2. CATARACT AND THE EYE

A cataract is clouding of the eyes natural lens, due to the build up of proteins on the surface, that over a period of time causes reduced vision. This can be cured by replacing the natural lens with an artificial lens, an "intraocular lens (IOL)", although the same complication can then still occur on the IOL after a period of time

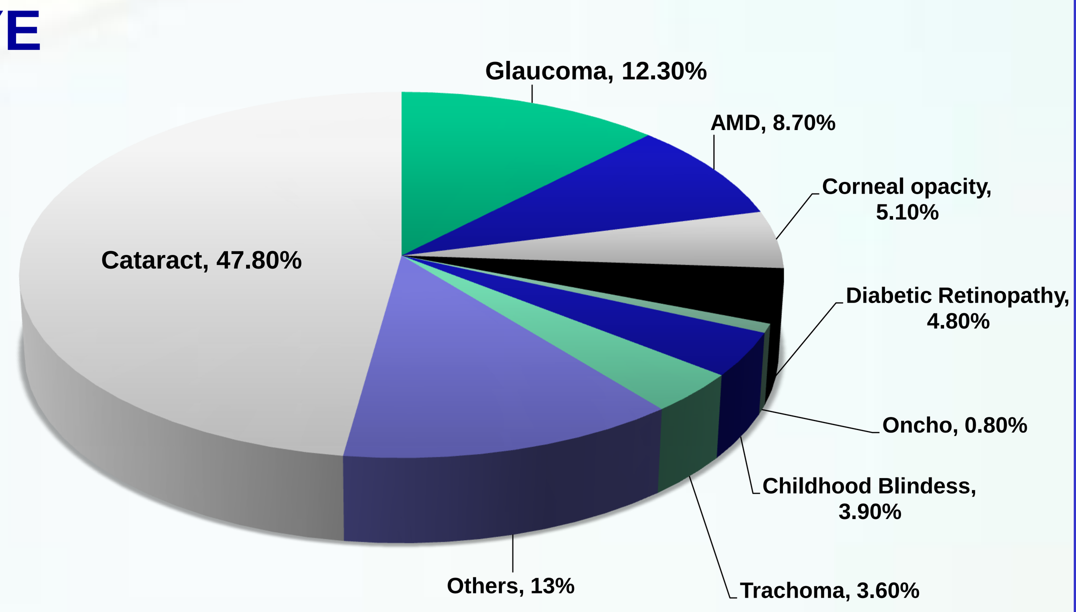


Fig 2: Causes Of Visual Impairment Worldwide

3. CALCIFICATION OF INTRAOCULAR LENSES

Calcification is the build up of deposits of calcium on the surface of an IOL, causing repeated blurred vision. Calcification results in the need for repeated cataract surgery. If research can identify the causes of the calcification it will be able to help in improving the materials and increasing the lifespan of IOLs

Fig 3: IOL

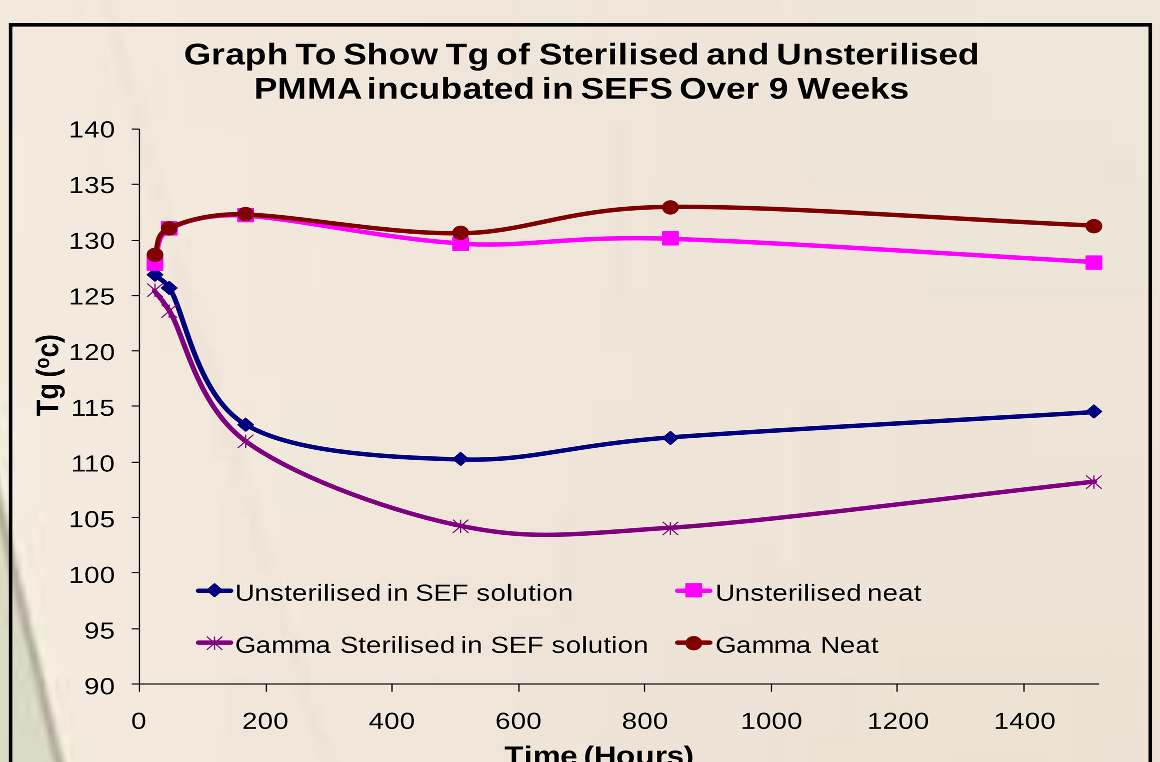
4. AIMS

The aim of this research was to contribute to investigations into the causes of calcification. The scope and extent of calcification was examined by using various surface and thermal analysis techniques. Comparing these to neat controls provides a good understanding of the rate of calcification.

5. METHODS

Poly(methly)methacrylate (PMMA) in disc form (10mm x 2.5mm) was sterilised using gamma radiation and also left un-sterilised. These were immersed in a Simulated Eye Fluid Solution (SEFS), ($CaCl_2$ 3.87mM, K_2HPO_4 2.32mM in tris buffer at pH 7.4 at 37ºc) used to study the rate of calcification over period of 9 weeks

6. THERMOMECHANICAL ANALYTICAL TECHNIQUES



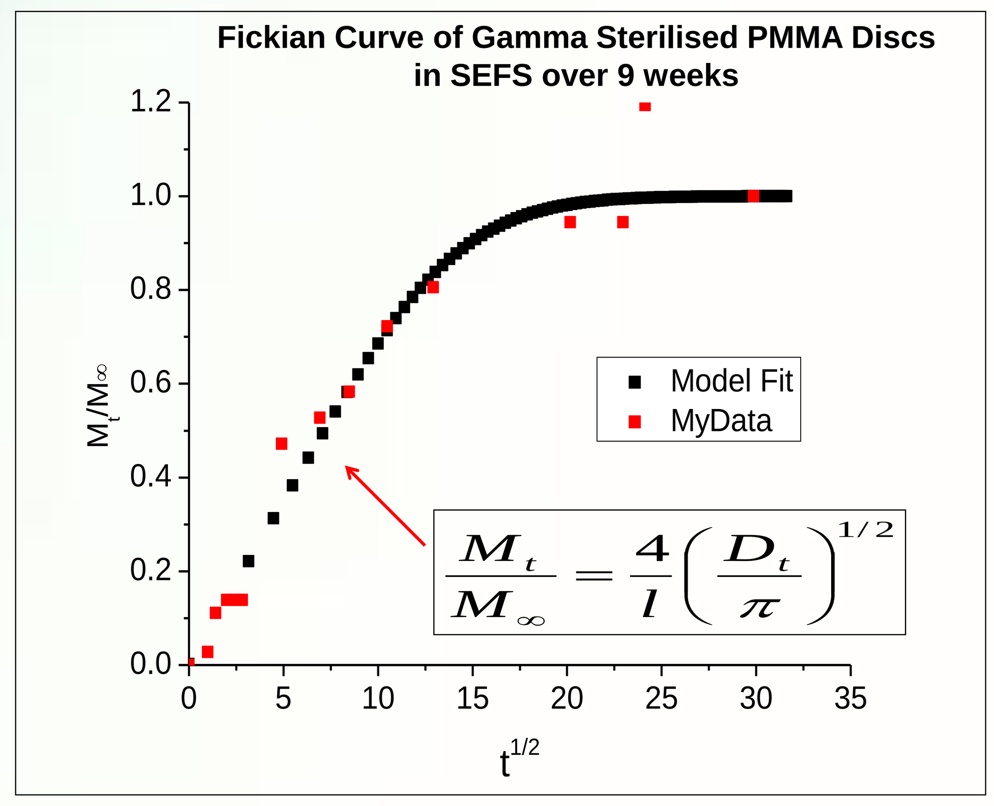
Thermal Mechanical analysis (TMA) -Used to derive the Glass transition (Tg) of PMMA, which contributes to plasticisation (softening). Plasticisation is important for IOL's as it determines the physical state of the polymer. PMMA discs immersed within the SEFS show a decreasing Tg over the period of 9 weeks, which could be accounted for by diffusion of water into the PMMA.

7. GRAVIMETRIC ANALYSIS

This was carried out by calculating weight gain/loss of the PMMA discs over the period of 9 weeks. The Data obtained is showing a clear fickian profile whereby a diffusion coefficient can be calculated at the shorter times, using the following equation:

$$D = \frac{m^2 \pi \; l^2}{4^2}$$

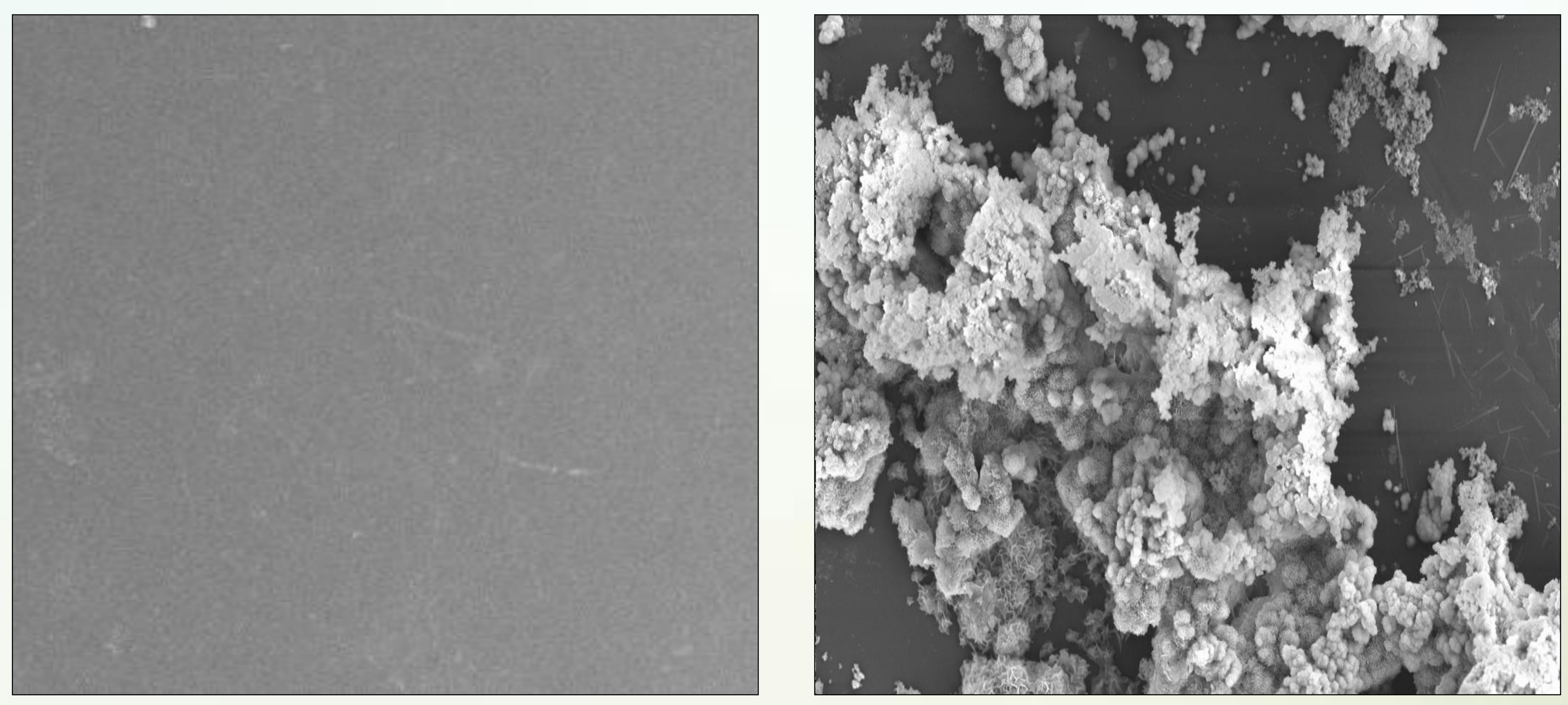
m = Gradient of Linear portion
l = Thickness of sample (0.0025m)
D = Diffusion Coefficient.



Gamma sterilised PMMA immersed in SEFS Diffusion Coefficient: 1.67 x 10^{-12} m^2 s^{-1}
Un-sterilised PMMA immersed in SEFS Diffusion Coefficient: 1.94 x 10^{-12} m^2 s^{-1}

8. SCANNING ELECTRON MICROSCOPY (SEM)

Images of impurities present on the surface, were observed as crystal like that started developing as soon as 1 day after immersion in SEFS. These deposits were identified by Energy Dispersive X-Ray Analysis (EDXA) as calcium containing



(A) (B)

Fig 4: SEM images of un-sterilised PMMA disc (A) and a sterilised PMMA disc with calcified deposits

9. CONTACT ANGLE ANALYSIS

Used to capture a water droplet falling onto the surface of a polymer, to give an indication of the degree of hydrophilicity of the polymer. From the contact angle analysis it was noted that the discs within the SEFS over a period of time had a decreasing contact angle, which is an increased degree of wettability.

(A) (B)

Fig 5: Diagram to show contact angle of Gamma sterilised PMMA after one day immersion in Buffer, measured as 44º (A) and Contact angle of Gamma sterilised PMMA after 9 weeks immersion in Buffer, measured as 32º(B)

References

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