·Basic Research·

Morphological investigation on AcrySof Natural's protective function from acute retinal light injury

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Abstract

• AIM: To investigate whether the Acrysof Natural has the protective function for retina from blue light in morphology.

• METHODS: Fresh porcine eye cups were formed *in vitro*. Blue light beam between 420-450nm spectrum eradiated the porcine retina and retinal pigment epithelial(RPE) cells were cultured in 30J/cm^2 and 40J/cm^2 respectively. The adjacent region in 3mm diameter was eradiated in various ways: exposed directly to light, through AcrySof one piece intraocular lens (IOL), PMMA IOL, AcrySof Natural IOL, and without light. Then the eye cups were cultured for 48h. Lastly, tissue and cell structure were observed with light microscope and transmission electron microscope (TEM).

• RESULTS: In the retinal region without light, the structure of every layer was clear; cells in neuroepithelial layer arrayed in order; some bubbles presented in external granular layer and internal granular layer; RPE cells were compact, and the color of pigment article was coincident. In the region with direct blue light and that with 30J/cm^2+Acrysof one-piece/ PMMA, cells on photoreceptor and external granular layer were lost partially, bubbles increased, RPE cells were of different sizes, and cell edema, cell lost and pigment article cluster could be seen. In region with 30J/cm^2+ Natural, a little disorganization could be seen compared to that without light, but more normal than those with Acrysof and direct eradiation. When the power was 40J/cm^2, the situation was similar to that with 30J/cm^2 but more severe.

• CONCLUSION: ① The blue light intensity in 30J/cm^2 and 40J/cm^2 could both induce the acute retinal light injury; ② AcrySof one piece IOL and other PMMA IOL have no obvious effect on retina compared with direct eradiation; ③ AcrySof Natural can weaken the injury of blue light to some extent.

• KEYWORDS: retina; light damage; AcrySof Natural

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INTRODUCTION

As established: light from environment can cause damages to the retina. The mechanisms of light damage have been studied extensively in laboratory studies, and were classified into two categories: long-term damage from low-intensity light and acute damage from high-intensity light. Light in blue spectrum is the main part for the damage [1,2].

For aged people, the lens becomes more yellow and filters most of harmful light including blue light. So the aging lens plays a protective role for retina from light. After removing the lens, the colorless intraocular lens (IOL) can block little blue light and the pseudophakic eye will subject to more dangers from blue light. In order to solve this problem, a new kind of IOL has been developed, such as AcrySof Natural. In order to define whether the IOL with yellow chromophore has the protective function for retina, we observed the retinal histology and ultrastructural changes and compared the differences in morphology under the conditions that can cause acute retinal light damage through different kinds of IOLs.

MATERIALS AND METHODS

Three kinds of IOL were prepared: AcrySof one piece IOL, AcrySof Natural one piece IOL, PMMA IOL. They were all+19D. Six fresh porcine eye cups were formed *in vitro* and kept sterile (3 for 30J/cm^2, 3 for 40J/cm^2). Blue light beam between 420-450nm spectrum eradiated the porcine retina in 30J/cm^2 and 40J/cm^2 respectively. In the same eye cup, adjacent region of posterior pole in 3 mm diameter was eradiated in various ways: exposed directly to light, through AcrySof one piece IOL, PMMA IOL, AcrySof Natural, and without light. The distribution map of retinal blood vessels was drawn and the eradiated zone was marked. Then the eye cups were cultured for 48 hours. After that, tissue and cell structure were observed with light microscope and transmission electron microscope (TEM).

RESULTS

Light Microscope The retina without eradiation: the tissue structure of each layer was very clear; in the neuroepithelial layer, cells were arranged regularly, some bubbles presented in external granular layer and internal granular layer, RPE

cells were compact, and the color of pigment article was coincident (Figure 1).

The retina with blue light eradiation in 30J/cm^2: photoreceptor cell lost; nuclear pyknosis could be seen thickening in outer nuclear layer; cells loss occurred in internal granular layer, and bubbles increased obviously (Figure 2). In RPE layer, the size of cell was different, cell swelling, cell loss, cell edema, pigment article cluster could be seen (Figure 3). In the section at a higher dose-40J/cm^2, RPE cell became denser, and cells' boundary was not clear (Figure 4).

In the part of AcrySof one piece and PMMA IOL at the dose of 30J/cm^2 blue light exposure, the histological appearance was similar to those eradiated directly.

For the retina under AcrySof Natural one piece, we could see there were still some injuries compared with the control retina. But compared with the retina under AcrySof one piece and PMMA IOL, cells in every layer were arranged comparatively in order; less pyknosis could be seen in outer granular layer; in interplexiform layer (IPL), there were a few small bubbles (Figure 5). RPE cells were comparatively compact, cells had the same size and the pigment looked equal (Figure 6).

TEM In the part without eradiation: the outer segment membrane disc of rods and cones was arranged comparatively in order. In outer nuclear layer, cells were compact, cytoplasm was equal, and little pyknosis could be seen (Figure 7). In RPE: the margin of endoplasmic reticulum was clear, melanin body distributed equally, and no melanin granule cluster could be seen (Figure 8).

In the part with blue light eradiation directly at 30J/cm^2: the outer segment membrane disc of rods and cones was arranged disorderly, polarity disappeared and cell loss occurred in many sites (Figure 9). In outer nuclear layer, cells were arranged compactly and orderly, but pyknosis could be seen, cell loss was also evident. In RPE cells: swelling of mitochondria could be seen; melanin body lost their apical distribution, and many melanin granule clusters could be seen; nuclear concentration and a lot of cytoplasm lysis could also be seen. In the group with AcrySof one piece and PMMA IOL, the circumstance is similar to that eradiated directly. The ultrastructural lesion can be seen.

For those in AcrySof Natural one piece group: the outer segment membrane disc of rods and cones was arranged comparatively in order; in outer nuclear layer, cells were compact, and cytoplasm was generally equal (Figure 10). In RPE cells: melanin body distributed comparatively equal, and there were a small quantity of melanin granule clusters (Figure 11).

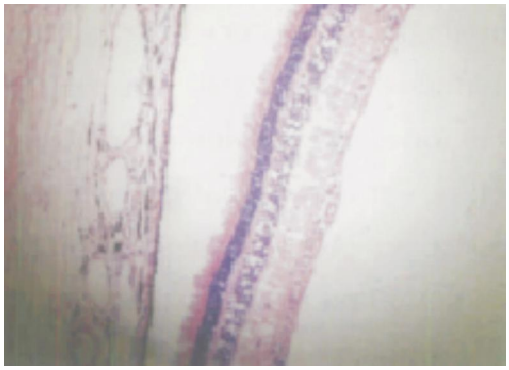

Figure 1 Retina without eradiation : tissue structure was very clear, cells were arranged regularly, RPE cells were compact, the color of pigment article was coincident ×20

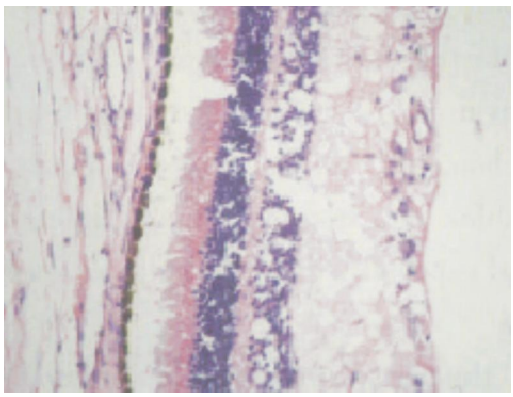

Figure 2 Retina eradiated in 30J/cm^2 : photoreceptor cell lost; nuclear pyknosis, thickening in outer nuclear layer; lots of cells lost in internal granular layer; bubbles increased obviously×40

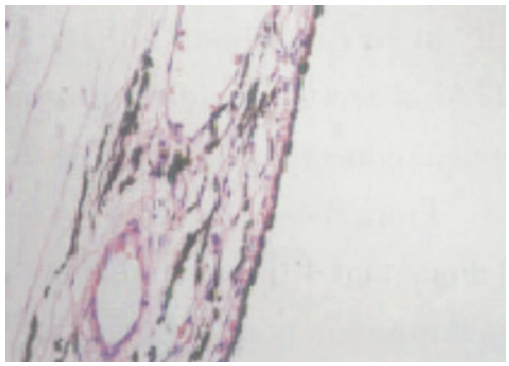

Figure 3 In RPE layer, cells were different, edema, loss, pigment article cluster ×40

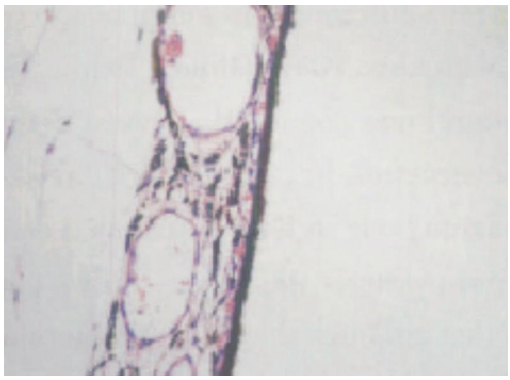

Figure 4 40J/cm^2: RPE cells became more densed, cells' boundary was not clear×40

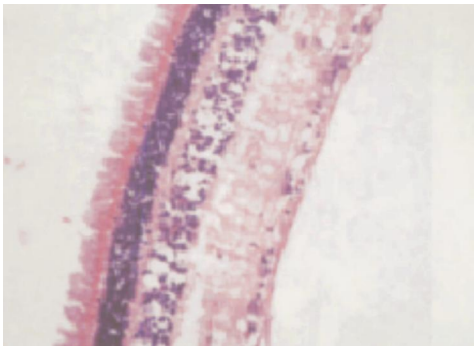

Figure 5 30J/cm² +AcrySof Natural: cells were arranged comparatively in order, in outer granular layer less pyknosis could be seen, and in interplexiform layer there were a few small bubbles ×40

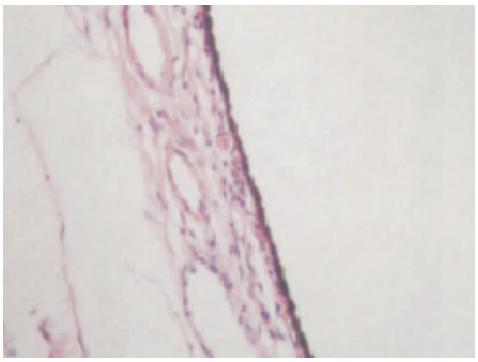

Figure 6 30J/cm² +AcrySof Natural RPE: RPE cells were comparatively compact, cell size was generally same, the pigment looked equal ×40

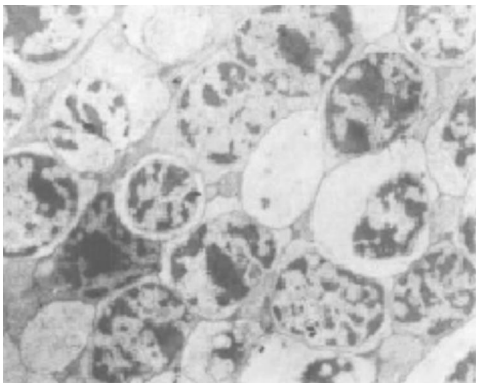

Figure 7 Without eradiation : in outer nuclear layer, cells were compact, cytoplasm is equal, and little pyknosis could be seen ×6 000

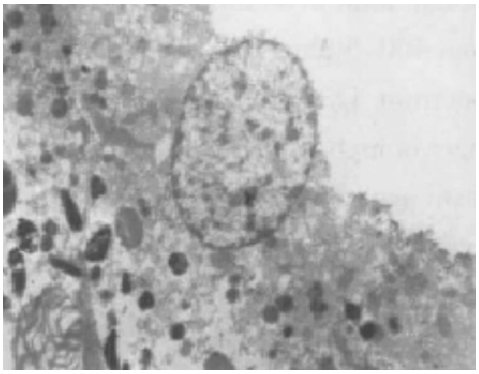

Figure 8 In RPE: the margin of endoplasmic reticulum is clear, melanin body distributed equally, no melanin granule cluster can be seen

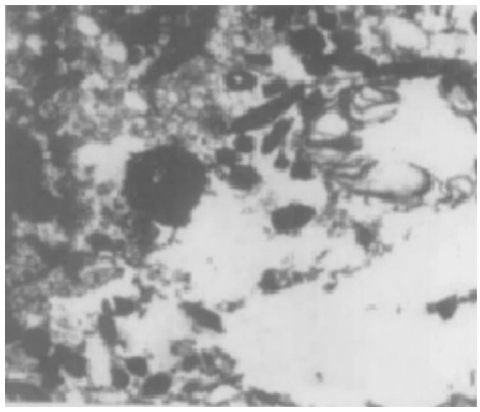

Figure 9 Retina eradiated directly at 30J/cm²: the outer segment membrane disc of rods and cones arranged disorderly, the polarity disappeared, cells lost in many sites

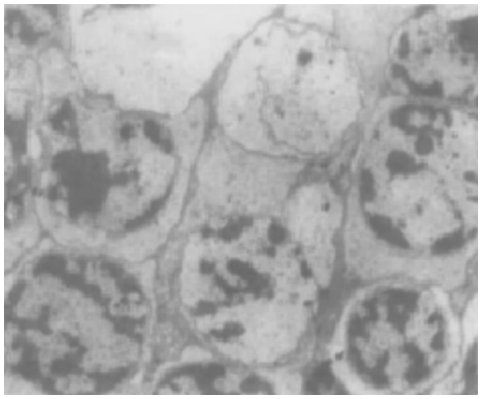

Figure 10 30J/cm²+AcrySof Natural: the outer segment membrane disc of rods and cones arranged comparatively in order; in outer nuclear layer, cells were compact, and cytoplasm was generally equal

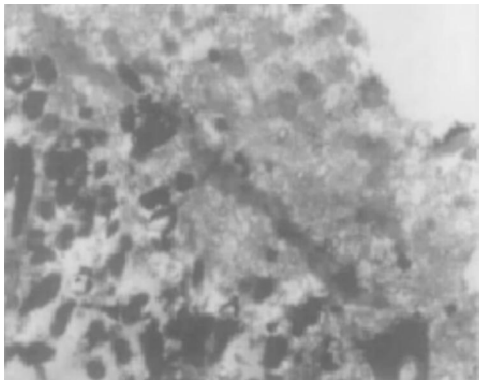

Figure 11 30J/cm² +AcrySof Natural RPE : melanin body distributed comparatively equally, and there were a few melanin granule clusters

DISCUSSION

It's well known that in addition to UV, some of visible radiation could also cause much damage to retina, in which blue light is the most important part. This damage mechanism is thought to be dependent on the absorption of photons by RPE [3]. The metabolism of RPE cells includes phagocytosis, lipofuscin accumulating and A2E in lipofuscin

gathering. Radiation of blue light in high-intensity could activate oxidation, develop free radical, and cause abnormal apoptosis which is the direct result of light damage. It could lead to apoptosis and metabolism disorder. The blue light-inducing damage on RPE could mainly cause the photoreceptor dystrophy, atrophy, vision lesion, etc [4,5]. On the other hand,it is demonstrated through many experiments and clinic investigations that exposure to light in blue spectrum is one to the causes for age-related macular degeneration(AMD) [6-8].

The normal adult crystalline lens could partially filter light of 400-500nm, especially the UV and light in blue spectrum. This function could help the retina avoid the danger of high powerful photon radiation. With the increase of age, the lens' color becomes deeper, and the lens becomes a more effective filter of short wave light. But the aphakic or pseudophakic eyes without the natural barrier would face much more dangers of light damage [5].

IOLs transmit an unnatural, even toxic amount of light in the eye in that bandwidth. With the development of IOL marketing, most of IOLs could already block the ultraviolet light from the sun, but light in blue spectrum which has been proved to have the most damages on the eye is not filtered [9,10]. In order to remedy this defect, a kind of new colored IOL was designed and produced-AcrySof Natural. It is added 0.4g/L light-absorbing chromophore designed to approximate the light-transmittance characteristics of the natural crystalline lens at wavelengths below approximately 500nm. Apart from this, it is identical in design and material with its predecessor-AcrySof one piece. This characteristic ensures the retina to obtian the maximum protection from light injury.

In this experiment, we chose the corresponding different parts as the control and treating zone in order to eliminate individual differences and to ensure the comparability to the maximum extent. During the tissue slice observation, we could see that the tissue structure was very clear. Cells were arranged regularly except for some bubbles in external layer and internal granular layer, and especially the RPE cells were compact and coincident.

However, the parts with blue light radiation in 30J/cm^2 and 40J/cm^2 intensity changed a lot: nuclear pyknosis and thickening occurred in outer nuclear layer; many cells lost in internal granular layer; bubbles increased obviously; especially in RPE, pigment article cluster could be seen.In TEM observation, chondriosome was injured, and nucleus concentrated, and the cell was injured seriously. From these we can see the blue light intensity in 30J/cm^2 and 40J/cm^2 could both induce the acute retinal light injury in porcine eye. On the other hand, the tissue slice observation through light microscope and TME under AcrySof one piece has no obvious difference in morphology compared to the retina with direct eradiation, while those under AcrySof Natural one piece IOL showed definite differences: the structure of neuroepithelium was well-arranged, melanin body in RPE distributed comparatively equally, and pyknosis was seen. So we can draw the conclusion that although the retina tissue under AcrySof Natural IOL is also injured a little compared to those without radiation, the injury is very light compared with the retina under AcrySof one piece/PMMA or radiated directly. Therefore AcrySof Natural could weaken the injury of blue light to some extent.

AcrySof Natural IOL inherits all the characteristics of AcrySof one piece. Moreover, it has the retina-protecting function, which could provide a much better vision for patients of cataract, especially those with both cataract and macular diseases.

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