The evaluation of the biocompatibility on the surface modified intraocular lenses

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Abstract—Objective **To develop a newly intraocular len, silicone intraocular lenses were modified with titanium and titanium nitride by the technique of surface modification.** Methods **In vitro cellular toxic experiment was performed with platelet adhesion, attachment and growth of macrophage, silicone oil adhesion to intraocular lenses.** Results **The modified intraocular lenses had less adherence to platelets, macrophages and silicone oil than the unmodified intraocular lenses.** Conclusion **The biocompatibility of the modified silicone intraocular lenses was improved by surface modification.**

Keywords—**surface modification, intraocular lenses, biocompatibility, in vitro**

I. Introduction

With the development of biomedical materials, there has been great progress in the materials, techniques and designs for manufacturing intraocular lenses. Silicone is one of the main materials for soft intraocular lenses (IOLs). However, there are still some problems related with the biocompatibility of silicone IOLs, such as hydrophobic and easily adherence to silicone oil. This study conducted surface modificaton on surface of silicone IOLs with titanium and titanium nitride, which biocompatibility of the modified silicone IOLs was evaluated in vitro.

II. Materials and Methods

This study used 36 silicone intraocular lenses (AMO), 12 IOLs as control group (unmodification), 12 IOLs modified with titanium (Ti) and 12 IOLs modified with titanium nitride (TiN) respectively by the technique of ion beam combined with low temperature and low pressure plasma.

A. Platelet adhesion

Each type (n=4) of IOLs was placed in 24-well tissue culture plates. 20 μl platelet suspension from fresh human blood was added on the top of each intraocular len (IOL) to sediment for 2 hours at 37 degrees Celsius in 5% CO_2 ambient. After rinsing three times with phosphate buffered saline (PBS, Ph 7.2), the number of attached platelets was counted using a 0.2mm×0.2mm grid located at the IOL center and was analyzed by variance, *F* test.

B. Attachment and growth of macrophage

Each type (n=4) of IOLs was placed in 24-well tissue culture plates. 20 μl cell suspension from mouse macrophage was added on the top of each IOL to sediment for 2 hours at 37 degrees Celsius in 5% CO_2 ambient. After addition of 0.5 ml of medium, the lenses were incubated for another 48 hours. After rinsing three times with phosphate buffered saline (PBS, Ph 7.2), the number of macrophages attached to the central area (0.04 mm^2) was counted and was analyzed by variance, *F* test.

C. Silicone oil adhesion

Each type (n=4) of IOLs placed in 24-well tissue culture plates was immersed in balanced salt solution for 12 hours and then for another 12 hours in silicone oil (5000). After removal from the oil each IOL was placed in distilled water and analysed with MIAS-2000 computer photography [1]

III. Results

A. Platelet adhesion

The number of platelets attached to the surface of unmodified IOLs was much more than that of Ti-modified IOLs (q=6.10, $P < 0.01$) and TiN-modified IOLs（q=6.59）, $P < 0.01$). There was not significantly between two modified IOLs grpups (q=0.49 $P > 0.05$), see table 1.

Table 1 The comparison of platelet adhesion

groups	n	X±S
unmodified	4	229.43±29.49
Ti-modified	4	146.30±24.28
TiN-modified	4	139.65±27.69

B. Attachment and growth of macrophage

The number of macrophages attached to the surface of unmodified IOLs was the most, there was statistically significant comparing with Ti-modified IOLs (q=4.65, $P < 0.05$) and TiN-modified IOLs（q=3.88, $P < 0.05$). There was not statistically significant between two modified IOLs grpups (q=0.78, $P > 0.05$), see table 2.

Table 2 The comparison of macrophage adhesion

M. Long (Ed.): World Congress on Medical Physics and Biomedical Engineering, IFMBE Proceedings 39, pp. 24–26, 2013.
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groups	n	X±S
unmodified	4	30.15±3.87
Ti-modified	4	21.78±3.35
TiN-modified	4	20.10±5.47

C. Silicone oil adhesion

The coverage of silicone oil attached to the surface of unmodified IOLs was much more than that of Ti-modified IOLs ($q=17.07$, $P < 0.01$) and TiN-modified IOLs ($q=19.60$, $P < 0.01$). There was no significantly difference between two modified IOLs grpups ($q=2.54$, $P > 0.05$), see table 3.

Table 3 The comparison of silicone oil adhesion (%)

groups	n	X±S
unmodified	4	57.75±4.18
Ti-modified	4	24.98±4.59
TiN-modified	4	20.10±2.33

DISCUSSIONS

Biocompatibility means a compatibility to life and is defined as "the capability of a prosthesis implanted in the body to exist in harmony with tissue without causing deleterious changes" [2-5]. Good or bad of biocompatibility of biomaterials depended on the interaction of material and tissue of human body. Intraocular lenses biocompatibility was thought to be determined on interaction between the lenses surface and local ocular tissues. Biomedical material contacting directly internal environment of human body should have no toxicity, no irritation and no carcinogenicity to human body [6-8]. Cell culture is known as one important method to evaluate the biocompatibility of materials.

The biomedical material implanted into human body may induce foreign-body reaction, which attachment and growth of macrophages was thought to be a foreign-body reaction to the IOLs and an important indicator of the biocompatibility of the IOLs materials [9]. It appeared in this study that the modified IOLs prevented attachment and growth of macrophages to the IOLs surface and induced lower foreign-body reaction.

The biocompatibility of material also included blood compatibility, which platelet adhesion was an important parameter evaluating the blood compatibility of the IOLs material. The results showed that the amount of platelets adhesion on surface of modified IOLs were less than that on the surface of unmodified IOLs. Therefore surface modificaton increased antithrombogenicity of the modified IOLs and enhanced biocompatibility of the modified IOLs.

Adherence of silicone oil to an intraocular len may be harmful, which could obstruct the vitreoretinal surgeon's view into the eye intraoperatively and could also lead significant visual loss. It was the need to choose an appropriate IOL biomaterial for a patient with present or potentially severe vitreoretinal disease likely required intervention with silicone oil. Our data demonstrated that the modified IOLs showed significantly less coverage and adhesion of silicone oil, which indicated that modified IOLs may be used more widely in clinical.

The silicone IOLs modified with titanium and titanium nitride respectively by the surface modification technique showed less adhesion of platelets, macrophages and silicone oil, then had a better biocompatibility.

IV. CONCLUSIONS

This study results in vitro showed that the modified silicone IOLs improved the biocompatibility of IOLs by surface modification.

ACKNOWLEDGMENT

A Foundation for the Author of National Excellent Doctoral Dissertation of PR China (FANEDD) FANEDD (200264).

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