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Dynamics of Morfological Changes in Eyeball Components During Insertion of Shape Memory Implant in Experiment

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1 Introduction

The latest advanced technologies for treatment of diverse eye diseases, including glaucomas, shall be based on evidence-based medicine findings, and, undoubtedly, the morphological methods (histological, histochemical, morphometric) are comprised in it.

Introduction of a new class of implants and structures of nickelid titanium (TiNi) in eyeball tissues as a drainage material for hypotensive treatment of refractory glaucoma forms has been an understudied subject in ophthalmic surgery and microsurgery in this area. In this view, we have performed an experimental morphological study of various eyeball structures at different periods of implant insertion.

2 Material and methods

The subject of research was examination of 21 rabbits of "chinchilla" breed of both sexes aged under 2 years. The reference group included 8 healthy animals. The animals and experimental work were executed in compliance with the requirements of Declaration of Helsinki for animals handling and in accordance

with International ethic and scientific quality standards for planning and conducting studies in animal. The surgery was done under the general anesthesia. Anesthesia was performed by intramuscular administration of Zoletil 100 solution, instillations were done with inocaine. The implants were prepared on the day of surgery, and sterilized by autoclaving. We implanted various material designs: super elastic permeable porous TiNi-based implant of 50-70% porosity and pore dimensions 100-400 μm and monolithic TiNi, cross section 0.1 mm. The suture material was used with thread diameter 40 microns. The implants were introduced intraocularly (intrascleral, intracorneal administration).

Histological examination of eyeball structures followed the algorithm below: 1) lesion localization (conjunctiva, cornea, sclera); 2) the intensity of necrotic lesions in the implant area; 3) the intensity degree of inflammatory response in the implant area and around it; 4) occurrence and severity of reparative processes in the implant area and around it; 5) the vascularization degree in the affected area and around it.

To accomplish it, we studied the morphological material obtained in the experiment after different time periods (3 days, 3 weeks, 6 months, 1 year, 2 years).

3 Results and discussion

3 days after implantation of TiNi structures in the eyeball, the following changes were revealed. In conjunctiva, there were superficial sites of coagulation necrosis in columnar epithelium impregnated with plasma proteins, fibrin, and single leukocytes. In the submucous membrane, among the foci of minor stromal cells necrosis and the foci of muscle fibers, granulation tissue development was recorded of represented by thin-walled capillary type vessels, isolated arterioles with vessel budding signs. Around small-size vessels, there was pericyte hyperplasia revealed looking like "spider" and star-shaped cells with small nuclei. It was noticed that the newly-formed thin-walled capillary vessels were filled with blood, and signs of stasis were seen.

In deeper layers, among the muscle tissue, there were lymphocytes and histiocytes. Collagen fibers were swollen sometimes fragmented. The glands mechanism was preserved, the cells were hyposecretive with signs of degenerative changes.

In cornea, within the same experiment period, the stromal edema was observed, hyperemia of small capillary and arteriolar vessels, degenerative changes in cornea cells. In sclera tissue, the edema of loose connective tissue and dissociation of collagen fibres were seen.

3 weeks after TiNi structures implantation in the eyeball, the following morphological picture was observed. In conjunctiva, small foci of coagulation necrosis in columnar epithelium and in the underlying submucosa areas. In some foci in areas of columnar epithelium cells damage, their regeneration was seen with "overlying" of survived cellular elements on the damaged structure. In the submucous membrane, single lymphocytes and histiocytes were revealed and a mild stroma edema.

In eye cornea, a loose connective tissue was seen comprising thin collagen fibers, thin-walled capillary and arteriolar vessels with swollen endothelial cells and their focal hyperplasia. In eye sclera, edematous loose connective tissue and individual thin-walled capillary vessels were recorded.

Within the following 6 months and 1-2 years after the surgery, the reparative regeneration was observed in the eyeball that included the recovery of the columnar epithelium layer in conjunctiva, the development of a vascular network of capillaries and arterioles containing blood cells in the submucosa. At the same time, in cornea a loose connective tissue was recorded comprising a small number of fibroblasts, thin collagen fibers, small capillary vessels.

Therefore, the experimental study based on surgical introduction of implants and TiNi structures in the eyeball and assessment of morphological eyeball changes at different periods after the surgery revealed the features of reparative and regenerative processes.

It was discovered that granulation tissue appeared within the early period after the surgery around the areas of coagulation conjunctiva necrosis containing thin-walled blood vessels with budding signs, and most crucially, without a severe acute inflammatory response (sterile inflammatory reaction).

It was noted that a comprehensive cell regeneration in the conjunctiva columnar epithelium and its submucosal structures was based on neovascularization that was prominent within the first 3 weeks after the surgery.

Minor damage of cells, fibers of the stroma tissue in cornea and sclera, active neovascularization, reparative epithelium cells regeneration within the first 3 weeks after the implants insertion in the eye evidence that this method of surgical treatment is favorable for a fast restoration of eye structures and can be recommended for practical use.