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The Use of Porous Polysulfone as a New Material for Intraorbital Implantation

V. B. Pisarev, Kh. Kh. Mukhaev, and A. K. Brel'

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Porous polysulfone is tested in animals for use as an implant during the formation of the postenucleation stump. It is shown that such an implant not only becomes encapsulated as a foreign body but also forms a functionally active stromal-vascular-muscular block.

Key Words: *polysulfone; eye extirpation, implantation*

In addition to severe physical trauma, extirpation of the eye results in a serious facial defect, causing depression and affecting the patient's capacity for work. The absence of a prosthesis in the postenucleation cavity causes deformation of the orbital tissues. An appropriate eye prosthesis partially corrects the cosmetic defect after simple enucleation; however, its mobility is low, it often falls back, and the orbitopalpebral groove can be pronounced.

Ya. I. Prizhibyl'skaya and V. P. Filatov report that the mean volume of an eye prosthesis is 2.5 cm^3, while the volume of the eye itself is 6-7 cm^3. Therefore, to compensate for the difference in volume the orbital cavity should be filled with some plastic material [2].

A hollow glass sphere was the first implant to be proposed in order to fill the orbital cavity and to improve the mobility of an eye prosthesis after evisceration (Mules, 1884) and after enucleation (Frost, 1887). A wide variety of materials have been used since then for eye implants [3].

An ideal implant should completely fill the orbital cavity, be of simple design, smooth (a rough surface can damage the conjunctiva), light-weight, and smaller than the eyeball so as to provide a deep enough cavity for the eye prosthesis. In addition, it should fit the muscle infundibulum and be attached to the orbital tissues to prevent its ejection. There should be tight contact between the implant and eye muscles, on the one hand, and the eye prosthesis, on the other, in order to increase mobility of the prosthesis. The implant should induce a minimal inflammatory reaction and not be resorbed for a long time [3].

The contact between implant and eye muscles is most important, since it provides for synchronized movements of the stump and healthy eye. These movements are transmitted to the eye prosthesis, which markedly increases its effectiveness.

In the present study a porous polysulfone (PS) was obtained by frothing a 60% PS solution in chloroform at 110-120°C in a mold of given shape and size, which provided a homogeneous structure with a pore diameter of 1-2 mm. This material (transparent PS) was chosen because it meets all FDA requirements, is nontoxic, and has a low affinity for proteins.

Polysulfone has been used for the preparation of dialysis membranes [1,5] and to enlarge the crista of the alveolar process in animals [4]. We have been unable to find any published data on the use of this material for orbital implants.

In addition, PS was chosen because it is quite durable and plastic, has a low specific weight (the implant weighs about 0.3 g), can be machine-produced, and has a pore diameter of 1 mm, which is optimal for ingrowth of surrounding tissues.

Our aim was to study the interactions of muscular tissue and stromal-vascular components with porous PS in an animal model.

Chair of Pathological Anatomy, Volgograd Medical Academy.

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MATERIALS AND METHODS

Experiments were performed on 8 mongrel dogs (2-4 years, 8-12 kg). The animals were maintained in individual cages on the standard diet.

Implants were spherical (diameter 10 mm). They were sterilized in boiling water for 1 h. Enucleation was performed by the standard method. After surgery, the animals were in satisfactory condition and were able to eat a few hours later. All the wounds healed by first intention. The dogs were sacrificed 10, 40, 60, and 90 days after the surgery, and the tissues surrounding the implant were excised. Macropreparations were fixed in Bouin solution for 24-48 h, washed under running water, and dehydrated in 80 and 96% ethanols. Prior to embedding in paraffin, pieces of tissue were immersed in chloroform for complete removal of PS. Sections (5-7 μ thick) were stained with hematoxylin and eosin and after Van Gieson.

RESULTS

Young granulation tissue consisting of fibroblasts and fine collagen fibers oriented parallel to the implant surface had formed by day 10. Considerable amounts of serous exudate containing erythrocytes, histiocytes, macrophages, and occasional leukocytes accumulated in lacunae formed as a result of PS resorption. In some lacunae (located at the implant periphery) fibroblasts proliferated and formed delicate bundles binding to the capsule formed around the implant. Serous edema of the muscle fiber (MF) stroma and widening of capillaries were observed at the periphery of the connective-tissue capsule in the stump area.

On day 40, the capsule consisted of fine collagen fibers and insignificant numbers of cells and blood vessels. Granulation tissue was seen in the lacunae (Fig. 1). Serous edema at the capsule periphery diminished, MF were hypertrophied, and MF nuclei and endomysial fibroblasts proliferated (Fig. 2).

By day 60, the formation of the connective tissue capsule was complete. The capsule consisted of thick fibers oriented in two directions: parallel and tangential to the implant. Tangential fibers formed fine cords and enveloped the MF located round the implant.

Retraction of the capsule and of the connective-tissue elements in the lacunae occurred on day 90. The muscle formed well-defined bundles separated by thin layers of connective tissue. The volume of MF was smaller compared with that on day 60, and proliferation of MF nuclei and endomysial fibroblasts was insignificant. The muscle fibers were oriented in the transverse and parallel planes (Fig. 3), as is the case under normal physiological conditions.

Study of the stromal-vascular and muscular components of the tissues surrounding the PS showed, first, the absence of morphological manifestations of implant rejection; second, involvement of the stromal elements in the usual regenerating processes; third, filling of the implant lacunae with exudate and the subsequent formation of granulation tissue.

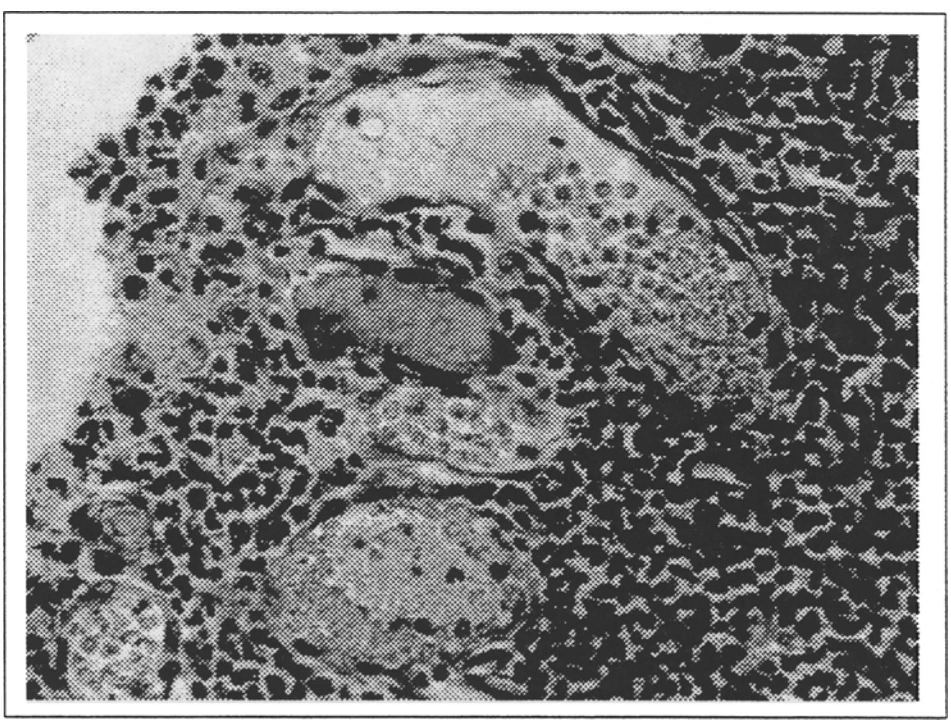

Fig. 1. Day 40 after surgery. Granulation tissue in the lacunae of the PS implant. Here and in Figs. 2 and 3: staining with hematoxylin and eosin, ×400.

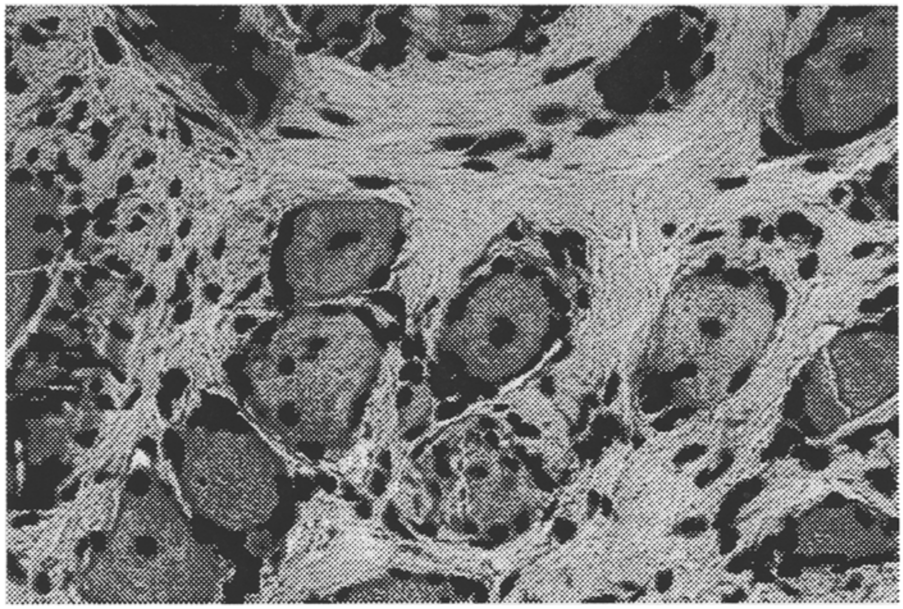

Fig. 2. Day 40 after surgery. Muscle fibers around the capsule. Hypertrophy of muscle fibers and hyperplasia of their nuclei and endomysial elements.

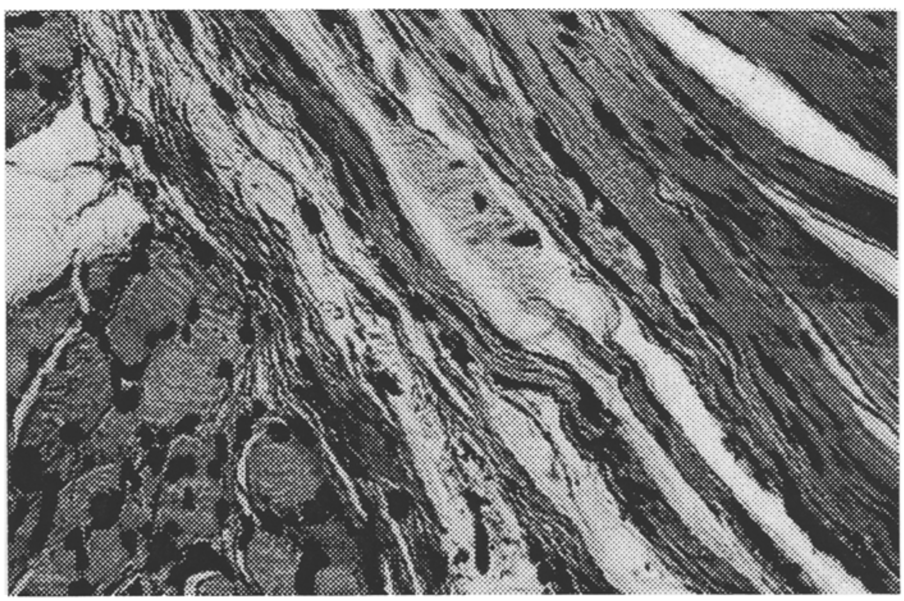

Fig. 3. Day 90 after surgery. Transverse and longitudinal sections of muscle fibers attached to the capsule.

Compensatory-adaptive processes in the muscle tissues around the implant were pronounced, indicating restoration of the MF cut during enucleation. The following mechanism may operate in this case: the connective-tissue elements accumulate around the implant, enter its lacunae, and bind to the connective-tissue capsule, while the elements of the capsule mingle with the connective-tissue elements of the stump, providing for rotatory movements of the implant as a result of various transformations of the stromal-vascular and muscular components.

Thus, a porous PS implant is advantageous, since it not only becomes encapsulated as a foreign body, but also stimulates the formation of a stromal-vascular-muscular block.

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