Pathomorphology of Subcutaneous Implantation of Basic Resin Specimens Modified by Glow Discharge

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Pathomorphology of reaction to subcutaneous implantation of basic dental resin plates with common and modified surface was studied in rats. Glow discharge treatment of basic etacryl resin improved the hydrophilic properties and biocompatibility of the polymer.

Key Words: *subcutaneous implantation of resin plates to rats; basic acrylic resin; modification of polymer surface; glow discharge; pathomorphology*

Surface properties of a removable plate denture with extensive contact with oral mucosa largerly determines the reaction of mucosa to denture [1-3]. Biocompatibility of all articles contacting with biological environment is evaluated by such parameters as architectonics (surface structure), chemical composition, physicochemical and energy characteristics of surface [9,10]. However, this latter characteristic is almost never used in evaluation of dental materials.

Specific free surface energy (surface tension) of a polymer, denoted as γ_S, is used as a criterion for evaluating surface properties of the polymer. This parameter is determined by the angle of surface wetting with liquid with known surface tension.

The range of γ_S values 20-30 din/cm or above 60 din/cm correspond to the best biocompatibility [6].

In experiments on rats we investigated tissue reaction to subcutaneous implantation of plates made of dental basic resin etacryl treated with glow discharge and not treated in order to modify free energy of the surface.

MATERIALS AND METHODS

Plates 10×2×1 mm with 5 holes 1 mm in diameter were made of etacryl, an acrylic copolymer-based resin. The plates were grindered and polished as removable plate dentures.

Some samples were treated in glow discharge, which increased wetting capacity of the polymer without modifying its basic physicochemical characteristics. Etacryl plates were treated with glow discharge on an experimental device consisting of high-voltage feeder, working reactor, and vacuum pump ensuring low pressure in the reactor.

Plate modification was studied by electron paramagnetic resonance (EPR) and infrared (IR) spectroscopy. EPR spectra were recorded on a radiospectrometer (Bruker) and IR spectra on UR-20 spectrophotometer.

In order to determine the energy parameters of test samples, contact wetting angle was measured under a horizontal microscope with an ocular fitted with a special scale. Drops of distilled water were pipetted with a micropipette onto test samples at 18-20°C [12]. Wetting angle for each group of resin was estimated from the results of 10 measurements. Maximal deviation in all cases was ±2°.

Pathomorphological study of tissue reaction to subcutaneous implantation of modified and intact samples of basic etacryl resin was carried out on 66 male Wistar rats (180-200 g). A longitudinal 12-mm incision was made between the scapulae under ether narcosis, subcutaneous fat was separated into layers with a blunt instrument, and experimental plates were placed into the pouch. The wound was sutured with silk.

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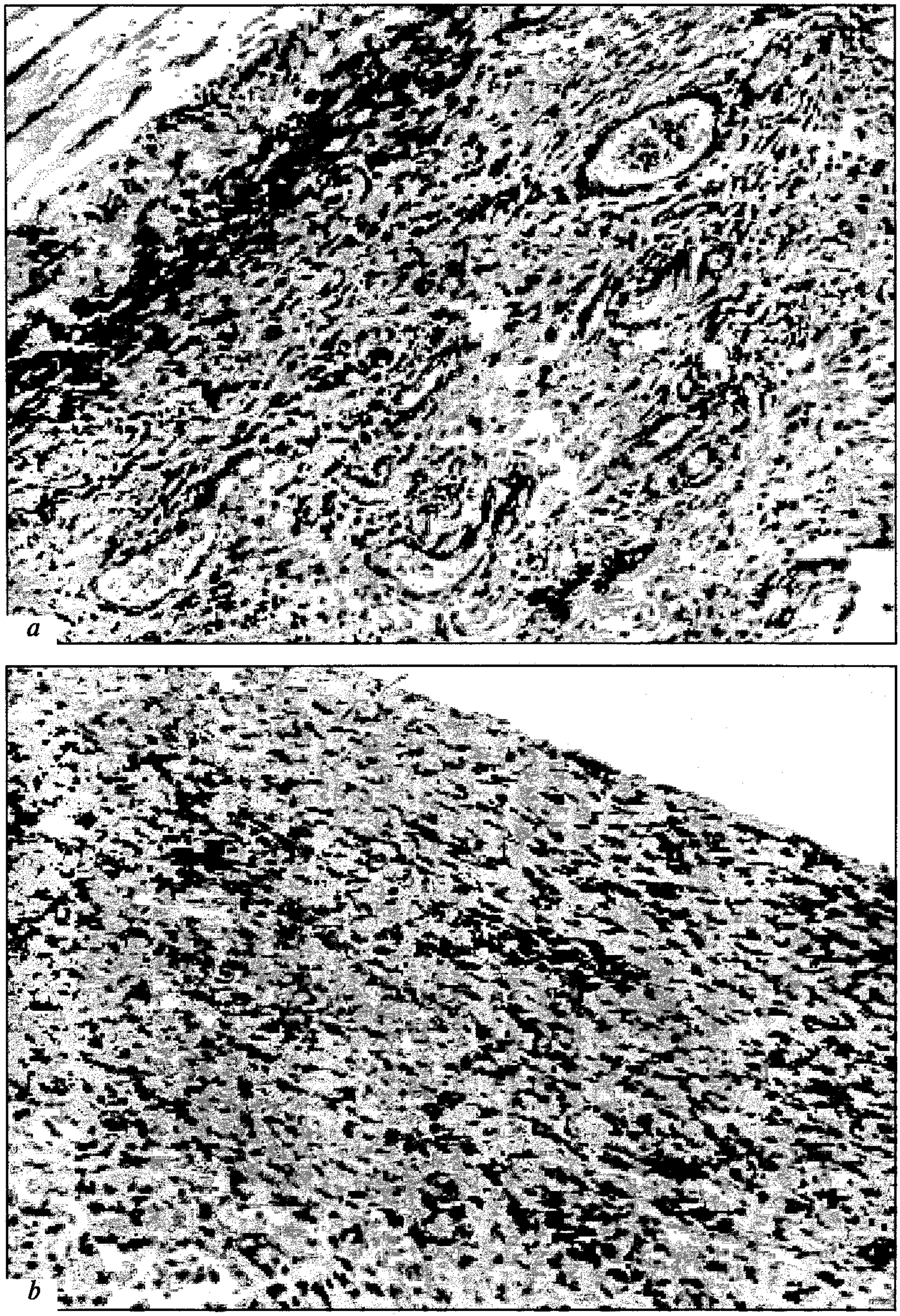

Fig. 1. Wall of capsule around plate implanted under the skin on day 8 of experiment. Staining: colloid iron—periodic acid—Schiff-hematoxylin, ×320. *a*) implantation of nonmodified plate (control). Fibroblasts, dilated capillaries, and sinusoids predominate in the granulation tissue; *b*) implantation of modified plate. Collagenization of the granulation tissue: no capillaries, accumulation of amorphous substance around fibroblasts.

Morphological study was carried out 7, 14, and 28 days postoperation: skin with adjacent tissues, including capsules coating the implant and fragments of viscera were examined. Samples were fixed in 10% neutral formalin. Paraffin sections were stained with hematoxylin and eosin in combination with Pearls' test and analyzed by combined colloid gold—periodic acid—Schiff-hematoxylin staining, which allowed differentiation between glycosaminoglycans and proteoglycans in tissues. Examinations and photographs were made under a universal NU-2 biological microscope.

RESULTS

The greater the wetting angle, the less is the degree of wetting of hard surface [4]. Wetting angles for initial

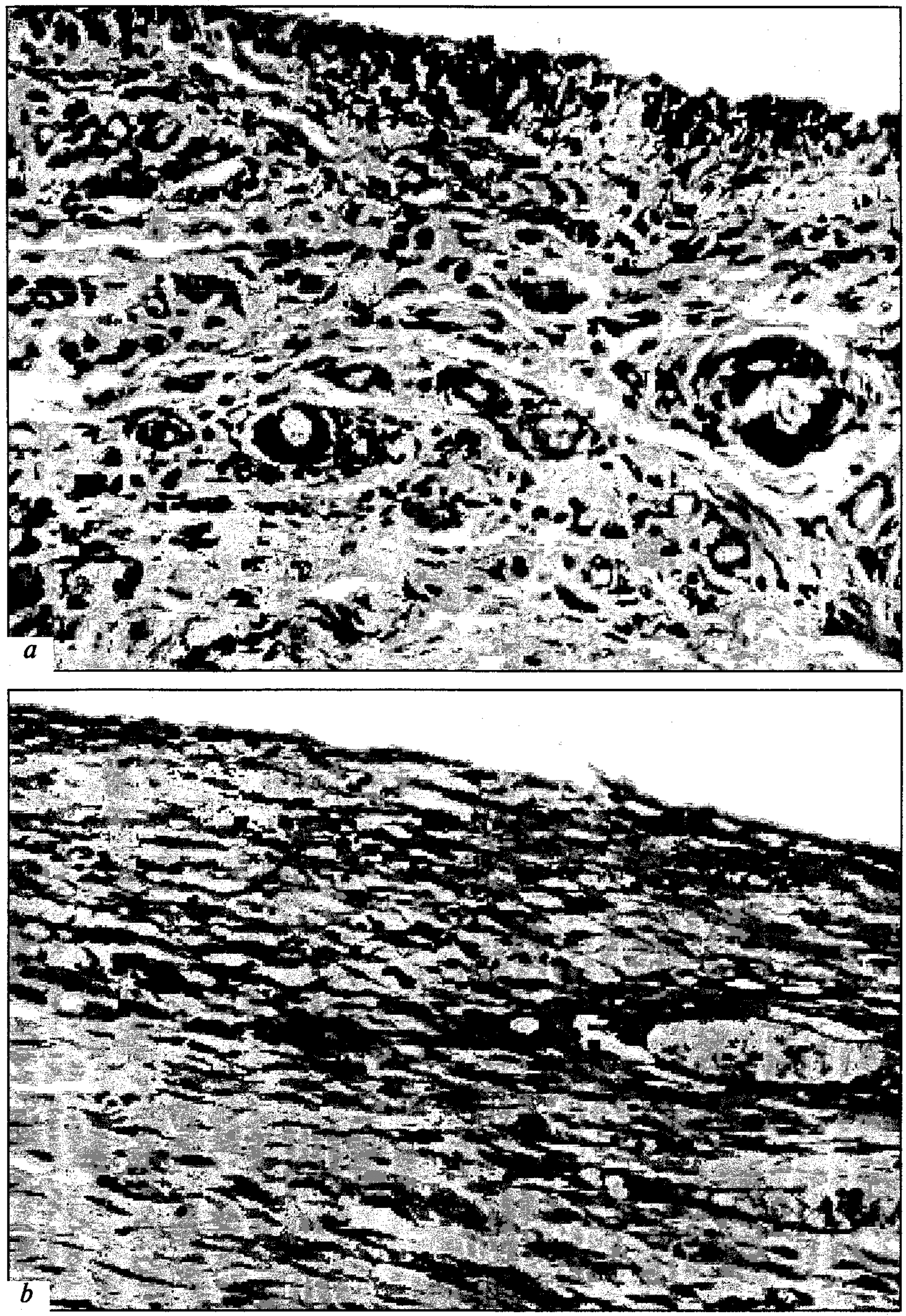

Fig. 2. Tissue reaction 14 days after implantation of plate. Staining as in Fig. 1, ×800. *a*) implantation of intact plate. Initial manifestations of collagenization in the granulation tissue around implant. Impregnation of vascular walls with plasma, small mononuclear infiltrations, and accumulations of mast cells; *b*) implantation of modified plate. Cell cicatrix of capsule around implant: scanty atrophic fibroblasts among wide collagen fibers.

and modified samples were 63° and 35°, respectively, *i. e.* surfaces of modified samples became more hydrophilic.

Marginal wetting angle θ is not sufficiently informative and demonstrative characteristic of polymer contacting with water or other liquid, as it is difficult to determine the critical θ_C value, below which the polymer can be considered biocompatible. Critical surface tension is a more informative parameter [6], but it does not sufficiently reflect hydrophilic-hydrophobic properties of the polymer. Free energy at the interface between polymer surface and fluid is preferable, since the general criterion of polymer biocompatibility can be obtained using this characteristic.

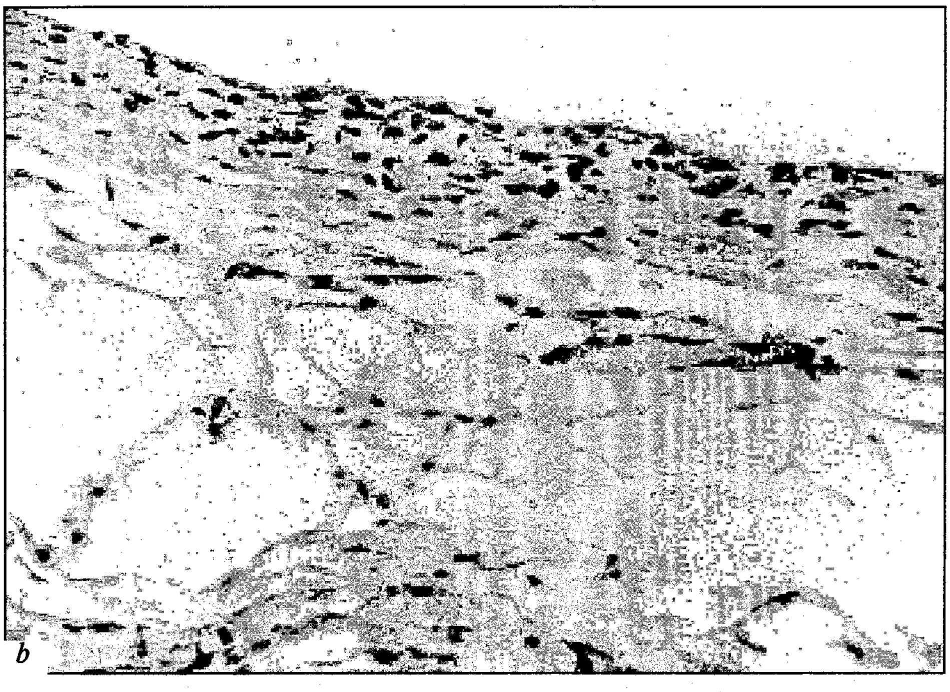

Fig. 3. Tissue reaction 4 weeks after implantation plate. Hematoxylin and eosin staining, ×800. *a*) implantation of intact plate. Formation of capsule by a cell cicatrix with thinning collagen fibers in the external layer; *b*) implantation of modified plate. The capsule is presented by a thin layer of cell cicatrix. External layers of the capsule are replaced by normal fatty cells.

Free energy at the phase interface can be evaluated by the formula [5,7,10]:

$$\gamma_{sl}=\gamma_s+\gamma_l-2\sqrt{\gamma_s+\gamma_l},$$

where γ_l is surface fluid tension (72.8 erg/cm^2 for water), γ_s free energy of hard body surface, which approximates critical surface tension γ_s [5] and can be evaluated by the formula [8]:

$$\gamma_s \approx \gamma_C \approx \frac{\gamma_l(1+\cos\theta)^2}{4}.$$

Free surface energy for modified and initial surfaces was 60.2 and 38.47 din/cm, free interphase energy was 0.6 and 5.43 erg/cm^2, respectively.

Hence, basic etacryl resin plates can be referred to hydrophobic materials and modified to hydrophilic.

Autopsy at all terms of examination showed no macroscopic pathological changes in organs. Microscopic structure of the lungs, heart, liver, kidneys, and spleen was normal in all rats: no degenerative and necrotic changes indicative of toxic effect were detected in these organs.

One week postoperation the implants were coated with a capsule densely attached to the skin (Fig. 1). Later it was difficult to isolate the implants because connective tissue grew into perforation of the plates (Fig. 2). By the end of week 4, the capsule walls became less plethoric and thinner; modified plates were clearly seen through thin connective coating (Fig. 3).

Examination of the implant capsules showed persistent aseptic inflammation in the granulation tissue round nonmodified implants during the first 2 weeks: neutrophilic leukocytes and macrophages formed microinfiltrations, new capillaries were dilated, focal erythrodiapedesis and edematous granulations were seen (Fig. 1). By the end of week 4 mononucleated infiltrates became smaller and less abundant, which indicated decay of the reaction (Fig. 3).

Aseptic inflammation in the granulation tissue around modified plates disappeared by the end of the second week (Fig. 2) and collagenization process was uneventful.

Hence, modified hydrophilic plates from basic etacryl resin were less irritative compared to nonmodified ones. Free surface energy should be taken into account when creating new dental polymers and using the known materials, which can be modified in order to render them the desired properties.

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