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THE INFLUENCE OF BIOLOGICAL ENVIRONMENT ON THE APPEARANCE OF SILVER-COATED IMPLANTS

ABSTRACT

Despite antibiotics preventive treatment before and after implantation, risk of infection is real. The infections at the implant surface developein a few months after applying them into the body. To prevent the development of bacteria and to reduce the risk of infection, implants coated with silver layer come into use. The paper presents the research results in biological environment on vein and orthopaedicimplants covered with silver.

Key words: vein implants, orthopaedic implant, silver, biological environment

INTRODUCTION

Silver was known for its antibacterial properties as long ago as in antiquity. The Greeks covered their plates and mugs with silver to prevent spread of diseases, and they already put silver coins into jugs of water to prolong the duration of the liquid. Greek children were given silver spoons to suck to prevent them from getting ill. In the 90`s of the 20th century scientists discovered that people with insufficient amount of silver in their bodies were frequently subjected to virus, bacteria and other illnesses. However, too much silver introduced into the body may result in necrosis of the liver tissues. An excessive amount of silver contained in food may cause blue-grey spots on the skin [1,2].
The heavy metals (iron, copper, zinc, manganese, silver and others) in too high contents have toxic effects, not only on the cells of highly developed organisms, but they can also slow down metabolic activity of primitive organisms. However, many heavy metals belong to so called trace elements, indispensable for the growth and proper functioning of cell metabolism [3-6].The microbes are capable of taking heavy metal ions from the environment and accumulating them in cells. Silver affects mainly the cell structural and enzymatic proteins. They are compounds responsible for the proper functioning of micro-organisms [7].
The in vitro research [8,9] proved increased efficiency of implants containing silver, used in bone fractures. Implants containing silver prevent bacteria adhesion on alien items introduced into macro-organism, as well as they have positive influence on the osteoblasts` activity.
Antibacterial properties of silver ions are useful in fighting against post-operation inflammations, caused mainly by bacteria:*Escherichia, Enterococcus* and *Pseudomonas* [10].
It is obvious that insertion of implants into human body carries the risk of bacteria infection, mainly as a result of biofilm formation on the implant surface. The first step to form the biofilm is bacteria adhesion. The appearance of biofilm on the surface may cause general

body infection in case of weak immunity resistance. Bacteria living in the biofilm structure are more difficult to be destructed by immunity system as well as are more resistant to antibiotics.
Bacteria affected by nanosilver cannot breathe, because the transfer of electrons in a cell is disrupted. Silver prevents metabolic reactions in bacteria cell, because it reacts with the –SH enzyme groups [4]. Even if such role of silver is well known, less is known on selective biological activity and strength of silver in presence of many different bacteria, which may together and in different contents appear in dangerous and frequent clinical inflammations. Therefore this paper is aimed to verify whether silver coat is effective in protection presence of as much as 5 different bacteria.To reduce the bacteria infection for people with vein problems, the firm AesculapChifa Sp. z o.o. introduced to the market antibacterial vein implants with built-in silver, one of them being a test object. Another specimen was the stainless steel implant covered with a thin silver layer.

MATERIALS AND RESEARCH METHODS

Two specific specimens for the research were: (i) polymer vein implant covered with silver, i.e. SILVER GRAFT (Fig.1) produced by AesculapChifa Sp. z o.o.and (ii) implant made of stainless steel (17.57Cr, 14.29Ni, 5.66 Mo) covered with silver (Fig.2).

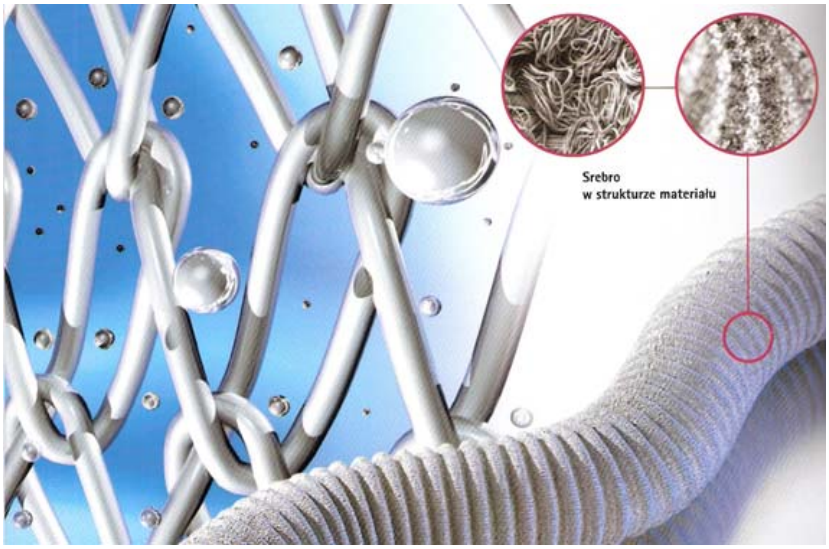

Fig. 1. Antibacterial vein implant SILVER GRAFT covered with silver (AesculapChifa Sp. z o.o.)

Fig. 2. The intramedullary nail covered with silver

Both implants were cut for the tests into pieces 10x15 mm. Afterwards the sterilisation was performed in the presence of steam under pressure in autoclave, at pressure of 0.2 MPa and at temperature134^{0}C for 10 min.
The test liquid comprised 5 the most frequent bacteria appearing in a human body: *Staphylococcus aureus, Staphylococcus epidermidis, Enterococcus faecalis, Klebsiellaoxytoca, Pseudomonas aeruginosa*. The base solution contained in 1 dm^3 of distilled water: casein pepton 17 g, pepton S 3 g, NaCl 5 g, K_2HPO_4 2.5 g, glucose 2.5 g. The pH value was maintained at 7.3±0.2. The specimens were dipped into bacteria liquid for the duration of 1 and 6 months.
The examination of surfaces after an exposure were made after with the scanning electron microscope Philips XL 30 in order to assess the bacteria presence and possible surface degradation.

RESULTS AND DISCUSSION

For the vein implant after one month exposure in bacteria containing liquid neither biofilm nor separate bacteriaare noticed. Only some dark spots, the remains of the bacteria liquid, covered the specimens (Fig. 3).

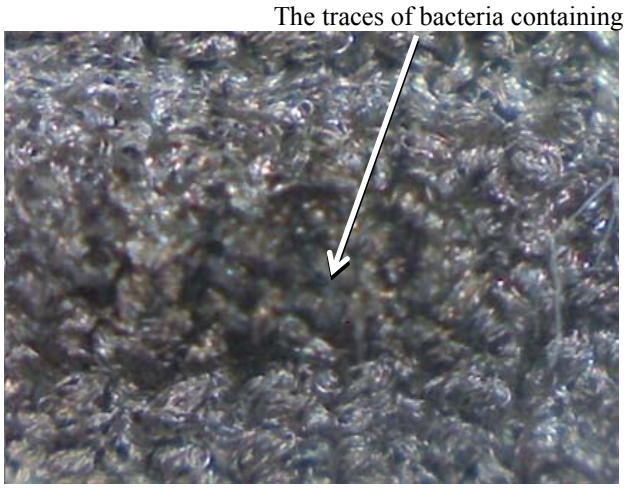

Fig. 3. The specimens taken out of the bacteria liquid after the period of 1 month

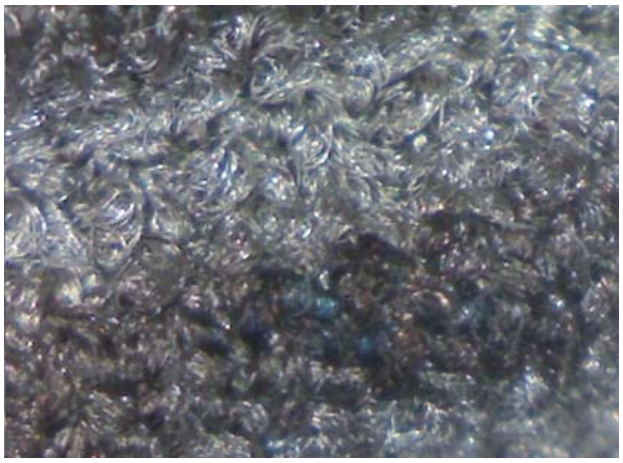

Fig. 4. The surface of a specimen removed from the test liquid after 6 months

After 6 months (Fig. 4) there was still no biofilm on the surface but single bacteria remained on the surface (Fig. 5).

Fig. 5. The separate bacteria among the fibres of the veinimplant: Staphylococcus aureus and Staphylococcus epidermidis

The results of microscopic examinations of the intramedullary nail implant present are presented in Fig. 6.

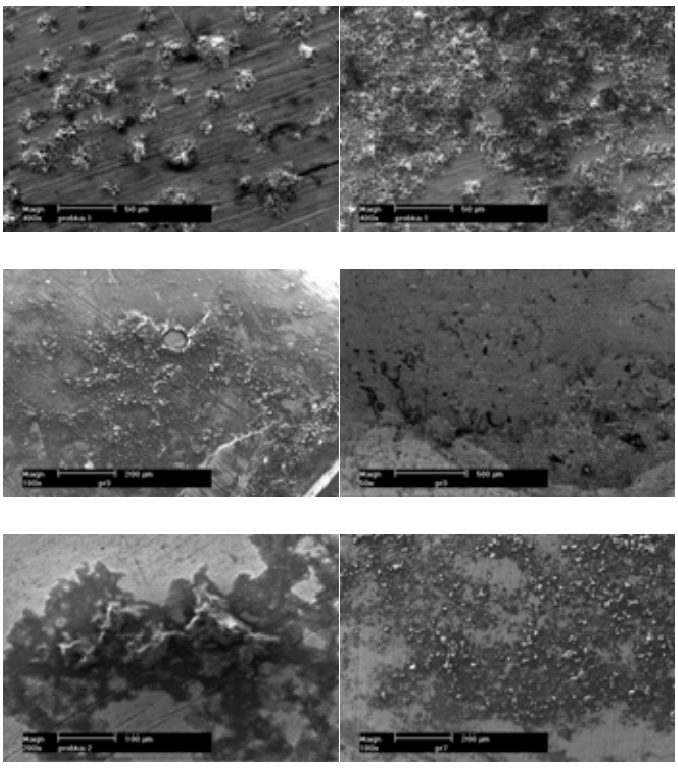

Fig. 6. The surface of the steel nail after 6 month exposure

The in vitro tests show the extraordinary effectiveness of nanosilver protection for both base material, polymer and stainless steel. The microscopic examinations of specimens disclosed bacteria colonies, which covered the material in the form of biofilm. After removing it there were no signs of material degradation.

The silver protection is demonstrated during an exposure as long as 6 months confirming that patients with silver coated implants do not need any additional antibiotic treatment. This silver coating protects implants against degradation in presence of all potentially dangerous bacteria. Such behavior may confirm the mechanism of protection, which is selective adhesion to the bacteria making their supply with oxygen impossible. It may explain why only silver particles of nanometric size may be efficient. In case of joint implants such protection may have then positive influence on the activity of osteoblasts.

CONCLUSIONS

Nanosilver coating is effective for an use on both polymer and metallic implants.
Nanosilver can protect base material against degradation in presence of *Staphylococcus aureus, Staphylococcus epidermidis, Enterococcus faecalis, Klebsiellaoxytoca, Pseudomonas aeruginosa*.
The protection mechanisms is likely via joining of silver nanoparticles with bacteria and destruct them by eliminating their supply with oxygen, and in such a way preventing them to adhere on the implant surface.

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