Influence of Implant Material on Electrical Biopotentials in Bone Fractures

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The increasingly wider scale use of various foreign materials in Orthopaedics and Traumatology require long-term study of their interaction with adjacent bone, with soft tissue, and also the integration of these materials into the bone tissue. One of the likely consequences of using implants and metal fasteners is the production of conductance disturbances of bone which are dependent on the type of material used, with major implications for its biology and by default on fracture healing. The purpose of this paper is to highlight the changes in focal bone fracture biopotentials depending on the chemical composition of biomaterials used. The study is experimental, on a group of 23 Wistar rats which were created femur bone defects that were repaired by autotransplantation of the hip bone with different wire set. The potential difference between the graft and the graft bed was measured and was correlated with the chemical composition of biomaterial. The largest potential differences were reported with aluminium wire, copper, and nickelin wire, while V4A wire (alloy of nickel, chromium and titanium) determined the smallest disturbance of these biopotentials.

Keywords: biopotentials, aluminium, copper, V4A, bone callus

In Orthopaedics and Traumatology, more than in any surgical specialty, therapeutic use of various foreign materials is increasingly common. These include bone material and its derivatives as grafts, plastics and others.

The use of metals in orthopaedic surgery is an important, well-known therapeutic mean due to the mechanical and chemical properties they possess. Their goal is to fix, to apply certain mechanical forces and to replace some parts of bone. Their presentation is varied: pins, screws, plates, nails or prostheses.

Recent references on this subject are surprisingly rare, despite the widespread use of various types of metal implants in both orthopaedic and dental medicine. In this area, the research on the use of biomaterials in orthopaedics, as well as micro current electrical influence on osteogenesis seeks to bring a number of new data useful in surgical practice [1, 2].

Ferrand, in a study on the different materials used in osteosynthesis, states that callus formation under the influence of intra-tissue electrical phenomena is known for many years, but the observations reported in this issue are quite rarely presented in the literature. The presence of the electrolytic phenomena occurring in bone tissue due to the existence of two different materials for osteosynthesis engage serious disturbances in the bone callus causing changes such as osteolysis. The processes occurring in these conditions remain largely unclear, theories are merely hypothesis [3].

Research on fracture consolidation produced disturbances due to various osteosynthesis materials were performed by our researchers [4].

Experimental part

Materials and methods

The research was conducted in the laboratories of the interdisciplinary research platform of USAMVB Timisoara on Wistar rats from our own biobase, which were measured bioelectrical micro current in the bone continuity solutions, which were transplanted grafts fixed with different materials. Recordings were performed with laboratory equipment. Due to very low voltage of such micropotentials, we used an electronic milivoltmeter with great inner resistance of 1012-1014 ohms, in order not to short circuit the device. We used a calomel electrode, which was placed in contact with the upper or lower bone to bone defect created and the second electrode directly on the biomaterial. Bioelectric recording was made during the intervention and immediately after killing the animal. Were operated on a batch of 33 rats, of which 4 have succumbed during surgery and 6 on the route from septic complications, remaining only a total of 23 for use. Anesthesia was achieved by Inactin, administered in an amount of 2-3 mg per 100 grams of body weight, and intervention went as follows: incisions made on the lateral side of the thigh to reveal bone, than performing small bone defects of 0.5-0.8 cm at the medium third of the femur. Then hip bone autografts were prelevated, then transplanted on these solutions in femoral bone continuity. Fixing these small autogenous transplants was done with different materials by wiring, due to excessive bone fragility is not possible to use other fixation devices (plates with screws). Animals were sacrificed at regular intervals from one week to 6 weeks. Histological sections were prelevated from each experience animal.

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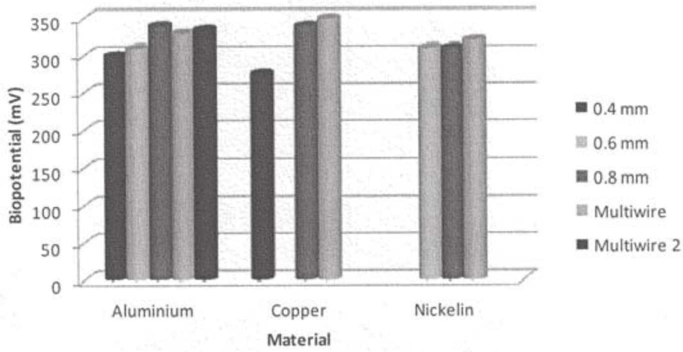

Fig. 1. Electric potential of different kinds of implanted materials with standard thickness, depending on their chemical composition

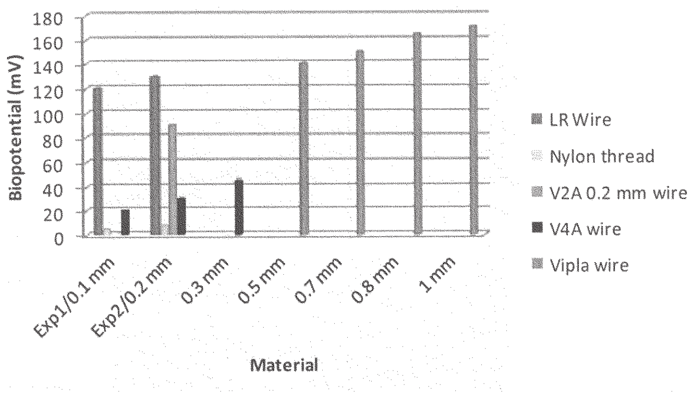

Fig. 2. Electrical potential of non-standard wires used in implants, compared to nylon threads without electrical conductivity

Results and discussions

Potential differences between the two determinations (during intervention and after sacrifice have suffered variations of 8-10 mV. In all cases we recorded bioelectrical values higher than those from the bone. Even the best metal materials that are currently used in practice trauma, such as V2A or V4A wires, are not electrically neutral. The graphs in figure 1 and 2 represent the values recorded of bioelectrical potentials in the experimental group of animals used depending on the composition of the material.

The analysis of our results shows that no material is perfect for fixture, with bioelectric voltages ranging from 350mV in copper wire to 5.8 mV in the nylon thread. Also worth noted, V2A and V4A wires that are used in surgical practice have the potential of 90 mV, while 0.2 mm diameter wire V2A and V4A wire diameter 0.1 mm, 20 mV.

These materials can disrupt the process of ossification that occurs at the junction between the transplant and recipient bed as they have variable actions that can ultimately lead to death of bone tissue. It seems that the materials with higher voltages bone cause polarization currents, from metal to the bone and do extend beyond the phenomena of their physiological resorption, thereby preventing deposition of salts.

Electrolysis process triggered in metal is also linked to the body's internal environment *p*H. This would explain why the osteosynthesis material is tolerated by some patients and not tolerated by others [5]. Studying the effect of these metals on ossification, we have seen that where transplants were fixed with various means of retainers the time for consolidation was prolonged by about 10 days.

Chamay [2] states that the action of electricity in a living tissue is complex and difficult to analyze. However Becker [6] showed that collagen fibers are able to migrate, to orient and polymerize in an electric field. In addition, several recent studies show the potential involvement of lesion biopotentials in bone regeneration after fractures [7] and their influence on signal pathways that coordinate cell migration [8] or apoptosis [9].

Although electrolysis processes triggered by metal when placed in the internal environment in therapy are the subject of experimental and clinical studies and research, yet how they influence callus formation is not sufficiently clear, even if there is evidence of these influences [10, 11]. It is important in this context the chemical composition of the implant, titanium implants currently being considered as the most reliable and consistent with optimal integration both in orthopedic surgery and in dentistry, which is valid especially for long-term implants as well [12].

It is preferable to use metals that have the very small biopotential, given that disturbances in ossification processes occur when their voltage is greater than that of bone. Moreover, electric potential role in healing and bone regeneration can be therapeutically exploited, as electrical stimulation of bone formation in fracture zones is able to produce superior results than using growth factors alone [13, 14].

Conclusions

Different types of implants used in orthopaedics influence the bone electric biopotentials and the healing process.

Potential differences depend on the chemical composition of the implant material used.

The largest potential differences were reported with copper wire.

Titanium alloys with low thickness (allowed by the physical characteristics of the alloy) produced the smallest differences of potential, comparable to nylon threads devoid of electrical conductivity.

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