Conclusions

Pre-coarsening did not affect architectural parameters of the titanium dioxide scaffolds such as pore size or porosity. However, it significantly improved the compressive strength of the scaffolds. 5 h of dwelling at 1100°C followed by sintering at 1500°C for 20 h was found as the most favorable in terms of microstructural and mechanical properties of the scaffolds.

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CARBON FIBROUS MATERIAL FOR CARTILAGE TISSUE TREATMENT

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Abstract

The work presents in vitro and in vivo experiments related to the evaluation of the biological properties of the two groups of carbon fibrous (micro, nano) materials. We investigated the carbon materials in the form of a biomimetic scaffolds made from carbon nanotubes and a composite membrane made from carbon micro-fiber and biocompatible polymer to induce regeneration of missing cartilage tissues. Evaluation of biological properties of both materials clearly showed that carbon fibrous material is biocompatible with cartilage cells and stimulates regeneration of cartilage tissue.

Keywords: *cartilage, chondrogenic materials, tissue engineering, carbon fibrous composite*
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Introduction

Reconstruction of upper respiratory tract in case of neoplasms, traumas (of mechanical, thermal or chemical origin), as well as post-intubation and post-trauma stenoses is a medical problem, which still remains without a solution. The materials used so far (autogenic as well as plastic ones) fail to give results that would be satisfying for patients as well as doctors, in early as well as late follow-up. Developing a biologically active material for making up the defects in upper respiratory tract shall allow to reconstruct the defective structures, which occurred in patients due to neoplasms, as well as in treatment of stenoses or traumas of mechanical, thermal and post-intubation origin. As is it evident from our previous studies and papers of other authors, the carbonaceous material in fibrous forms (micro and nano) were successfully applied in the treatment of defects of cartilage. Numerous findings support the hypothesis that fibrous carbon components due to their unique chemical and physical properties (biomimetic form, functional groups on the surface, electrical conductivity, thermal conductivity, mechanical properties) can act as chondrogenic materials [1-7].

Materials methods

Our studies comprise in vitro and in vivo assessment of carbon micro and nano materials. The subjects of the experiments are membranes made of carbon fibers (micro-fibers made from PAN precursor, carbonized at 1100°C) and a biocompatible polymer (PVDF- polyvinylidene fluoride) – in vivo experiments. Carbon nanotubes - based scaffold has been prepared on a titanium substrate by use EPD method (Multi-Walled Carbon Nanotubes -MWCNT, length: 1-2 microns; outside diameter: 10-30 nm; were purchased from Nanostructured & Amorphous Materials, Inc., USA. MWCNT were chemically oxidized in concentrated H_2SO_4 and HNO_3 acids mixture) - in vitro tests. Human chondrocytes isolated from tissues of the larynx and trachea, collected during surgical procedures, were used for in vitro study. These cells were seeded with scaffolds prepared from carbon fibrous materials for various periods of time. In order to assess the impact of carbon materials on the cultured chondrocytes, cytotoxicity and genotoxicity tests were carried out. In vivo studies were carried out using carbon fibers /polymer membranes to rebuild experimentally prepared defects of the trachea of animals (sheep). The in vivo experiments were performed for various periods of time, from one to nine months. FIG. 1 shows chondrocytes adhering to the scaffolds made of carbon nanotubes, and FIG. 2 presents the histological image of tissue formed in the presence of the implant (carbon fibers/polymer membrane).

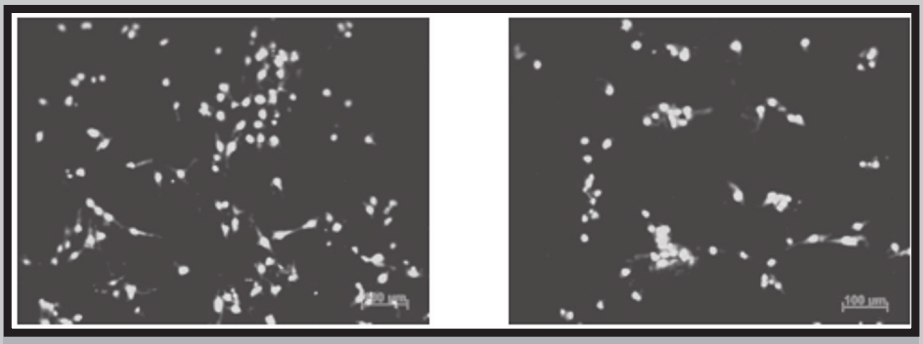

FIG. 1. Chondrocytes adhering to the surface of the scaffolds made of carbon nanotubes (acridine orange).

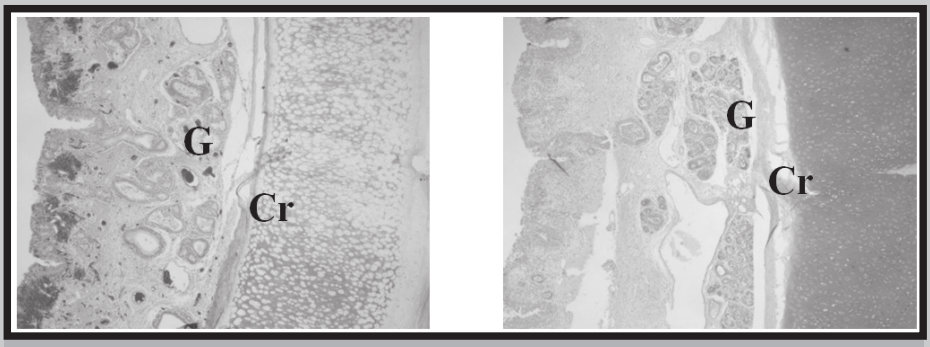

FIG. 2. Histological images of tissue formed in the presence of the implant (carbon fibers/biocompatibile polymer membrane), one month after implantation. Proper construction of the tracheal wall: stratified columnar epithelium, visible layer of active sero-mucous glands (G) and cartilage (C). Masson-Goldner staining of (A) and PAS (B), magnification 10x.

Results and discussions

The preliminary in vitro study indicates that all carbon fibrous scaffolds are neither genotoxic nor cytotoxic. The cells adhering to the scaffold made of carbon nanotubes retain the shape characteristic for chondrocytes. Analysis of tissue remodeling in contact with the composite; micro-carbon fibers / polymer, revealed the chondrogenic properties of the material. Cartilage tissue in contact with the carbon composite material includes elements such as the natural tissue of a tracheal tissue.

Conclusion

The positive preliminary in vitro and in vivo assessment of nano and microfibrous carbons indicates that such materials provide structures which seem to be promising as scaffolds for the treatment of cartilage.

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