ANTIBACTERIAL ACTIVITY ASSESSMENT OF BIOACTIVE MODIFIERS FOR BONE CEMENTS

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[ENGINEERING OF BIOMATERIALS 148 (2018) 58]

Introduction

Active biomaterials have an important role in modern medicine, because their using can reduce the risk of postoperative complications.

Apart from its main function, i.e. bone filling and fracture stabilizing, bone cement can also be applied as a carrier of bioactive agents. Then due to the releasing of the substances it enables: combating bacteria, protecting against microorganisms and treating local infection [1-3].

In this work, analysis of the bactericidal effectiveness of selected bioactive agents used as cement modifiers was performed.

Materials and Methods

The research was carried out on commercially available PMMA bone cement – Cemex (Tecres, Italy) and following bioactive additives were used:

- antibiotics /1.5w/w%/:
  - gentamicin (Sigma Aldrich, Germany);
  - ciprofloxacin (Sigma Aldrich, Germany);
- nanometals /5w/w%/:
  - silver nanoparticles – 50 nm (MkNano, Canada)
  - copper nanoparticles – 30 nm (MkNano, Canada);
- chitosan medium molecular weight particles /3w/w%/ (Sigma Aldrich, Germany).

Preparation of bioactive bone cements was conducted in accordance with previous study [1]. The additives were added to the powder and hand-mixing. Next the bone cements were prepared following the procedure by the manufacturer's recommendation. Then this obtained paste was placed into molds to ensure the required shape and allowed to cure for 1 hour in ambient conditions.

To determine the bactericidal properties of modified bone cements, the bacterial growth inhibition zone tests were performed. For research three clinical isolated bacterial strains were taken: *Staphylococcus aureus, Pseudomonas aeruginosa* and *Escherichia coli* (supplied by Specialist Hospital in Kościerzyna, Poland).

Results and Discussion

The porous structure of the bone cement enables the deposition of bioactive agents in it. Then, as a result of the flow and circulation of body fluids, the substance particles are gradually released into the environment [1]. Therefore, the porosity and the structure of cement have the greatest impact on the effectiveness of its bioactive ability, but also are the following features are important: the amount of substances used, its form and particles size [1,3].

Generally, the gold standard for commonly used bioactive biomaterials is the use of antibiotic additives. However, due to the growing problem of bacteria resistance, mutations and the formation of biofilm this method becomes problematic [2]. Therefore, currently other bioactive substances are sought. The following features are expected for this potential additives for biomaterials: a broad spectrum of activity, a lack of resistance, an ability to combat biofilm and a long therapeutic period [2]. On the other hand, it is important that these modifications do not interfere with biomechanical properties of biomaterial [1].

Nowadays, the only method for commercially available cement is the addition of antibiotics. However, other solutions are constantly searched and tested [1-3].

In this work, five types of bioactive agents used for modification of bone cement were studied:

0 – unmodified bone cement,
1 – bone cement modified with nanosilver,
2 – bone cement modified with nanocopper,
3 – bone cement modified with ciprofloxacin,
4 – bone cement modified with gentamicin,
5 – bone cement modified with chitosan.

A bacterial growth inhibition tests for common strains of bacteria were carried out (FIG. 1).

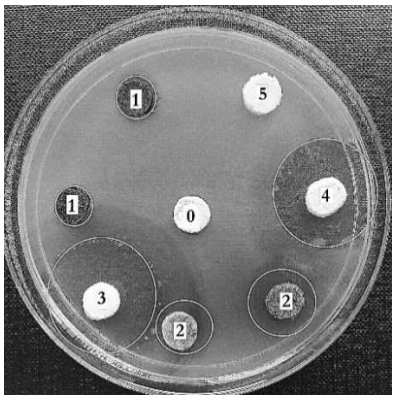

FIG. 1. Comparison of the bacterial growth inhibition zone for the tested specimens after 72 h; circles – visible growth inhibition zone

The bactericidal effectiveness of bone cements modified with antibiotics and nanometals has been confirmed (FIG. 1). The largest zone of bacterial inhibition was observed for the antibiotic - ciprofloxacin. However, the smallest for nanosilver. Moreover, the lack of efficiency was found for chitosan. The experiment lasted 7 days and both antibiotic-loaded cements and cement modified with nanometals maintained their activity during this period of time.

Conclusions

Modified bone cements can be used as carriers of bioactive agents and fight locally the bacteria. Hence, they can be used to treat infections or its prevention.

Acknowledgments

The authors would like to express their sincere gratitude to the Higmed Poland s.c. Company for scientific-research coopertation.

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