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Biocompatibility of Calcium Phosphate Coatings With Different Crystallinity Deposited by Sputtering

Authors : Ekaterina S. Marchenko, Gulsharat A. Baigonakova, Kirill M. Dubovikov, Igor A. Khlusov

Abstract : NiTi alloys combine biomechanical and biochemical properties. This makes them a perfect candidate for medical applications. However, there is a serious problem with these alloys, such as the release of Ni from the matrix. Ni ions are known to be toxic to living tissues and leach from the matrix into the surrounding implant tissues due to corrosion after prolonged use. To prevent the release of Ni ions, corrosive strong coatings are usually used. Titanium nitride-based coatings are perfect corrosion inhibitors and also have good bioactive properties. However, there is an opportunity to improve the biochemical compatibility of the surface by depositing another layer. This layer can consist of elements such as calcium and phosphorus. The Ca and P ions form different calcium phosphate phases, which are present in the mineral part of human bones. We therefore believe that these elements must promote osteogenesis and osteointegration. In view of the above, the aim of this study is to investigate the effect of crystallinity on the biocompatibility of a two-layer coating deposited on NiTi substrate by sputtering. The first step of the research, apart from the NiTi polishing, is the layer-by-layer deposition of Ti-Ni-Ti by magnetron sputtering and the subsequent synthesis of this composite in an N atmosphere at 900 °C. The total thickness of the corrosion resistant layer is 150 nm. Plasma assisted RF sputtering was then used to deposit a bioactive film on the titanium nitride layer. A Ca-P powder target was used to obtain such a film. We deposited three types of Ca-P layers with different crystallinity and compared them in terms of cytotoxicity. One group of samples had no Ca-P coating and was used as a control. We obtained different crystallinity by varying the sputtering parameters such as bias voltage, plasma source current and pressure. XRD analysis showed that all coatings are calcium phosphate, but the sample obtained at maximum bias and plasma source current and minimum pressure has the most intense peaks from the coating phase. SEM and EDS showed that all three coatings have a homogeneous and dense structure without cracks and consist of calcium, phosphorus and oxygen. Cytotoxic tests carried out on three types of samples with Ca-P coatings and a control group showed that the control sample and the sample with Ca-P coating obtained at maximum bias voltage and plasma source current and minimum pressure had the lowest number of dead cells on the surface, around 11 ± 4%. Two other types of samples with Ca-P coating have 40 ± 9% and 21 ± 7% dead cells on the surface. It can therefore be concluded that these two sputtering modes have a negative effect on the corrosion resistance of the whole samples. The third sputtering mode does not affect the corrosion resistance and has the same level of cytotoxicity as the control. It can be concluded that the most suitable sputtering mode is the third with maximum bias voltage and plasma source current and minimum pressure.

Keywords : calcium phosphate coating, cytotoxicity, NiTi alloy, two-layer coating
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