INCREASE OF BONE MASS AND OSTEOBLASTIC ACTIVITY AROUND TITANIUM IMPLANTS BY CONTROLLED PHOTOCHEMICAL IMPLANT COUPLING OF BMP-2 BY MOLECULAR POLYMER NANTECHNOLOGY IN A RABBIT MODEL OF IMPLANT OSSEOINTEGRATION

INTRODUCTION:

Normally the survival time of hip endoprosthesis can be assumed between ten to fifteen years. In the past there were several problems to achieve a proper osseointegration of implants, like in total hip replacement, especially in case of revision. The gap between implant and bone is very often the focus of loosening because of infections or other reasons which end up in a chronic inflammatory response and finally in bone resorption and mechanical failure resulting in severe pain. Very often we find large bony defects after removing the implant. One way to improve the integration of the implant into bone is to encourage bone growth to the implant surface by covering it with a biocompatible and bioactive thin polymer film. The polymer surface should then allow a direct adhesion of osteoblasts to close the gap between bone and implant early after implantation. In this study we present the first results of two different polymers connected with rhBMP-2 that are implanted in the tibia and femora of New Zealand White Rabbits.

METHODS:

In this study we designed cylindrical titanium implants with an inner thread (Ti6-4Al-4V, 3 mm hight x 3 mm diameter) that were coated with different polymers on their outer surface. The polymers were fixed to the surface using the photochemical method of grafting. Some of these films seem to improve the osseointegration after further functionalizing with bioactive substances like protein BMP-2 [1] for example. Recently photochemical grafting methods were developed for glass or silicon surfaces. To apply such photochemical grafting methods to titanium and its alloys the use of a phosphonic acid anchor instead of a silane anchor is favorable, because for biomedical applications the hydrolytic stability of the coating is important for long living implants. After functionalizing the implants using rhBMP-2 they were implanted in the proximal tibia and distal femora of New Zealand White Rabbits. Two different polymers were tested (PVBP [Polyvenylbenzylphosphonat], PVBP-Co-Acryloxsuccimid). The locations of the implants rotated to test the osseointegration in different quality of bone (cancellous vs. cortical bone). After 4 weeks the animals were sacrificed and DEXA-scans (Dual-energy X-ray absorptiometry), micro-CT and histological analysis were performed.

RESULTS:

In high-resolution DEXA-scans we found a difference in bone mineral density (BMD) between PVBP and a control implant in the distal femora and in the proximal tibia with an increase of bone mineral density.

In the histological investigation we found an increase of osteoblasts around the implants coated with PVBP and PVBP-Co-Acryloxsuccimid. Furthermore, the micro-CT scans showed an increase of BV/TV (bone volume/total volume) for both polymers.

DISCUSSION:

In this study we present our first results of the investigation of BMP2-coated titan implants implanted in the proximal tibia and distal femora of New Zealand White Rabbits. Therefore, different polymers were photochemical attached on the titanium surface of the implants. Afterwards they were functionalized with rhBMP-2. The results of the DEXA-scans and micro-CT showed an increase of bone around the implants. Our first results suggest that the coating of titanium implants and functionalizing with rhBMP-2 promote the osseointegration of implants. Furthermore, we think that this kind of surface modeling can reduce the risk of implant loosening, especially in total hip replacement and in the case of future revision surgery. In other studies, BMP was adhered to the implants by dipping into fluids containing BMPs. These authors found only small increases of bone around these implants. Therefore, we postulate that coating the implants after using the photochemical method of grafting with special anchors and different polymers is a good method to increase BMP bonding and the osseointegration, especially in cases of implant replacement. To get a closer look on the polymers and their characteristics in-vivo further investigations are conducted.

REFERENCES:


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Figure 1. DEXA-scan of tibia and femora of a New Zealand White Rabbits. We found a difference in bone mineral density (BMD) between PVBP and a control implant in the distal femora (PVBP 0,720 g/cm², control 0,661 g/cm²) and in the proximal tibia (PVBP 0,633 g/cm², control 0,431 g/cm²). The enlarged implant is coated with PVBP.

Figure 2. Micro-CT scans. (1) shows a control titan implant with no surface coating in the lateral femora. There is a gap between implant an bone. (2) and (3) show of the same implant coated only with PVBP [Polyvenylbenzylphosphonat] in the tibia. A gap cannot be seen in this reconstruction. We found an increase of BV/TV (bone volume/total volume) for both polymers. (4) is a 3-dimensional reconstruction of the same implant coated only with PVBP.