Strong magnets to investigate novel dental implants

Replacing lost natural teeth with dental implants is not a recent technological advancement. The implant history dates back thousands of years and includes the ancient Chinese, Egyptians, Mayans, Celtic and Etruscans civilizations. A variety of attempts and materials were used to replace lost teeth, e.g. teeth-like pieces of shell, ivory, wood, natural bone, metals and even stone were wedged into the gum or creatively carved artificial teeth of these materials were stabilized by gold wires to create a fixed bridge. The selection of material was based on its availability and the ingenuity of the person making and applying the implant. Considering, that the knowledge about suitable implantable materials and although the purity of applied metals had been rare and furthermore important basic concepts relating to infection and the biological reaction to materials were not yet established, the success of a prosthesis must have been a lucky coincidence.

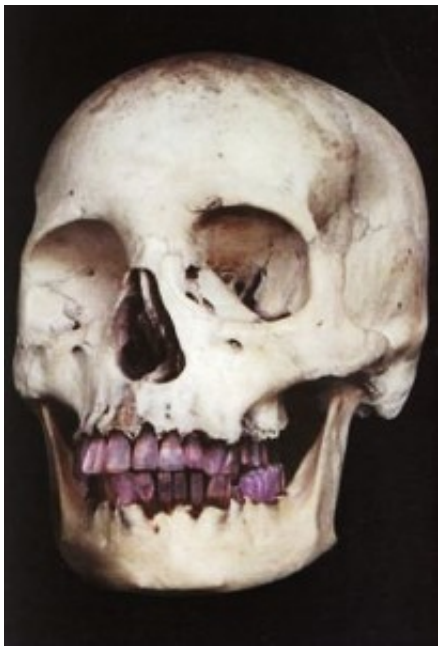

Fig. 1. Skull from the Peruvian Mochia culture with a complete dental restoration by rose quartz carved teeth. Museo del Oro, Lima. Image from (Hildebrand HF. Biomaterials - a history of 7000 years. BioNanoMat; 2013, 14: 119–133).

Only since the 1960s the specific research about design principles, synthetic strategies for reproducible materials, tissue properties and tissue-implant-interactions started by engineers, chemists, biologists, physicians and dentists. And the demand for novel materials is growing due to the demographic development.

To study implant-tissue-interactions and to assess the suitability of an implant animal studies are

indispensable. The investigation of novel implants currently is mainly performed with histological techniques. For that, just a few ten micrometers wide tissue sections, which include the implant, were prepared, specially stained and analyzed under the microscope. Unfortunately, these methods are destructive and do not allow for the investigation of living animals. Therefore, non-invasive imaging techniques like Magnetic Resonance Imaging (MRI) have gained interest in the field of material science.

Detailed pictures of internal tissues can be obtained without exposing the individual to harmful radiation using MRI. Due to its excellent contrast in the soft tissue the technique is well-established e.g. in the field of oncology. In implant dentistry MRI is not yet a standard imaging modality and it is a rarely used technique although in implant research. One important reason may arise from interactions of some implant materials with the MRI machine. To produce MR images a combination of powerful magnetic fields and radio waves are used. Especially implant metals like stainless steel or titanium interact with the radio waves of the MR system and lead to partially tremendous image distortions. To overcome this, the use of synthetic materials is recommended, because they are compatible to MRI.

Dental implants are mainly fabricated from titanium. If a patient wishes a metal-free implant a ceramic material will be used. Recently a synthetic polymer material named polyetheretherketone (PEEK) is discussed scientifically as a potential material for dental implants. PEEK is chemically stable, compatible to biological tissues and can be easily shaped to arbitrary devices. Over and above, the material is compatible to medical imaging and will not interact with the MRI machine.

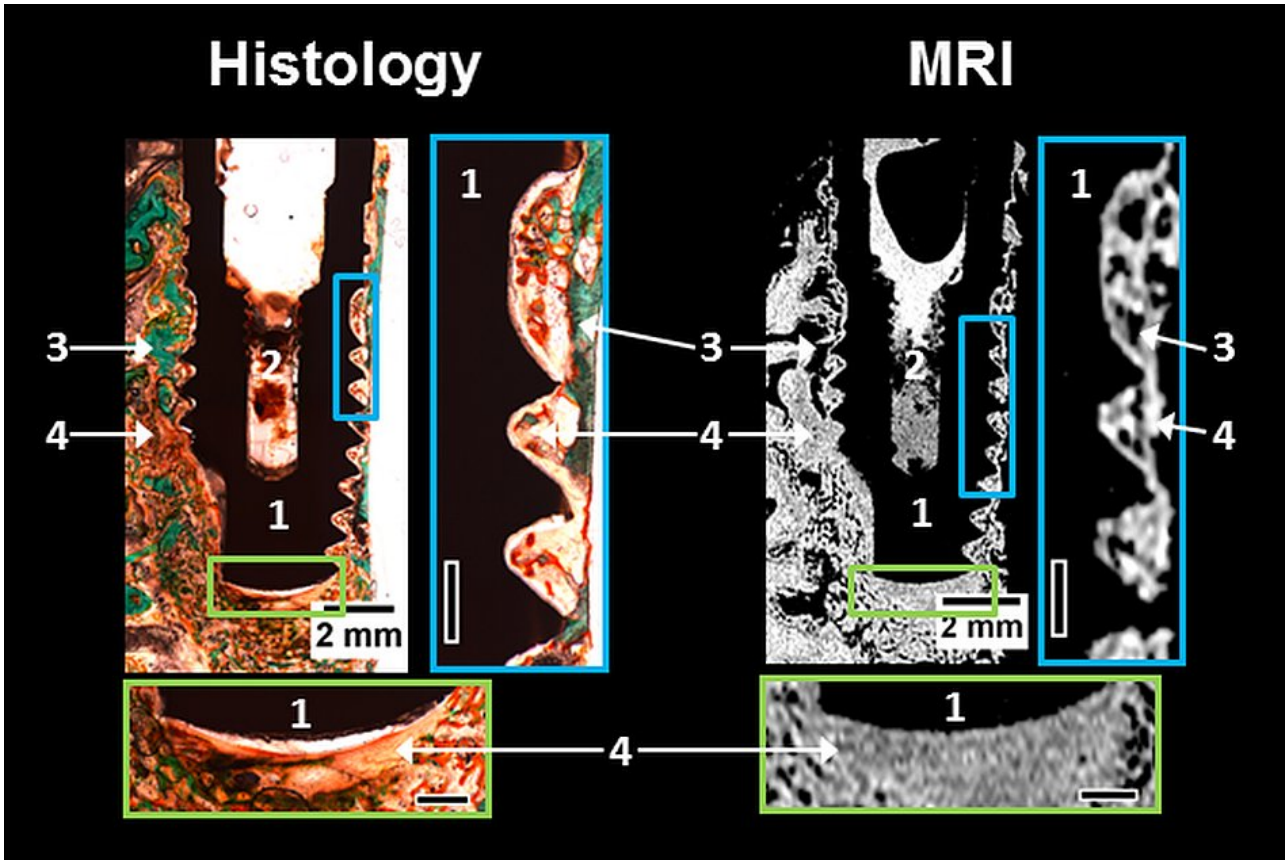

Fig. 2. Histological image (left side) and MRI slice image (right side) of the dental implant and the surrounding bone and soft tissue. The numbers display the following: 1-dental screw-type implant, 2-plant cavity, filled with water and soft tissue, 3- bone, 4- soft tissue. The scale bars on the magnifications represent 0.5 mm.

In our study we investigated three issues. Firstly, how far is MRI able to complement the information obtained by histology? In the study the dental PEEK implants were inserted in the lower jaw of minipigs. The healing process was assessed after two, four and eight weeks. We found comparable results for the quantification of adjacent bone volume for both, MRI and histology.

Secondly, which additional information is accessible by using multimodal imaging? Only MRI was able to differentiate between soft tissue, fatty tissue and bone in this case.

And thirdly, do dental implants made from PEEK show a satisfactory ingrowth into bone? The implants showed a sufficient healing into bone. Here, further studies to elucidate the long term survival of PEEK implants under loaded conditions are required to examine their potential application in implant dentistry.

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