Characterization of dental materials for clinical use

The aim of the research is to develop new types of dental materials for the purpose of dental fillings and to prepare the production possibility for a suitable material.

The main steps of the research targeted by the topic are:
Building on the knowledge of the molecular bonds of amorphous GIC, we would like to develop a new molecular structure that results in production of a material with clinically good properties. This requires the following technical steps:
- synthesis of amino acid chain / amino acid derivatives;
- determining the real structure of the bond between the modified amino acid chain variants and the filling at molecular level;
- exploring the relationship between electronic structure and mechanical properties;
- computer aided design of a modern filling material with good mechanical properties and long life;
- preclinical loading fractography and dissolution and edge gap studies;
- in vivo toxicity and tissue reaction studies.

Mechanical tests:
Although many studies have dealt with compressive – tensile and shear – loading, fracture, fatigue testing, (micro) hardness testing of GIC, studies similar to clinical loading were introduced by Wang and Darvell [2008] by exposing GIC samples to Hertz loading. The Hertz load is a controlled load with a metal ball that models, like the tooth tips and end bars, how the forces are transmitted by the upper support tips to the lower tip bars (three-point contact) or the end bar (two-point contact). According to the contact, the forces are concentrated on the doubly convex surfaces. Hertz loading is performed on GIC discs in two forms, conventional parameters as described by Wang and Darvell, where the GIC disc is 10 mm in diameter, 2 mm thick, the load ball is 20 mm in diameter, and the load is made by a machine of Zwich Z005, 121-001609 type at an approximation speed of 0.2 mm / min. The dentin base, which mimics the support of the disc, is provided by a 30% fiberglass-reinforced polyamide (nylon 6,6) material. The load is applied until the material is completely broken. On the loaded surface, the radial or conical course of the crack lines and the mode of propagation are performed by microCT, SEM and FTIR testing methods. In a similar experimental setup, a different type of loading is performed, where the loading is performed until the first cracks appear using audio control. For the NanoCT test, an order of magnitude smaller sample was prepared, where the size of the load transfer ball was only 2 mm.
Further mechanical studies support the resistance to the interaction between the filler and the polyacid chain, namely by the nanoindentation method on the surface of ion-polished filling material. With this assay, we can verify at the molecular level the fractographic properties of materials developed by computer design and candidate for clinical use. This molecular-level fractographic analysis is supplemented by SEM analysis.

Preclinical studies:
Edge gap (micro-gap) studies show how the material is able to adapt to the wall of the formed cavity and form a bond with it. Surgically removed, wisdom teeth with a whole crown are stored in 0.2% sodium azide solution at + 5°C until processing. We create a first-class cavity, which is filled with the GIC material to be tested according to the rules of the profession. The size of the edge gap is proportional to the volume of fluid flowing between the gap and the tooth material under Hagen-Poiseuille law. This method is particularly sensitive to the size of the gap, since the volume is proportional to the fourth power of the radius of the micro-gap.

The restored tooth is decoronated and the crown is placed in a double chamber and subjected to a hydrostatic pressure of 15 cm of water above the pulp chamber. From the chewing surface chamber, the liquid column is passed through a micropipette in which the displacement of the bubble per unit time shows the flow rate. This study shows, in the form of a follow-up study, an increase in gap formation due to dissolution of the substance (repeated at 3, 6, and 12 months). In the period between measurements, the samples were kept in artificial saliva, the composition of which was described by Professor Darvell. This experimental setup is also lucky because the spoke can be supplemented with a load test. Namely, in the range under the crack-causing load measured on the GIC disc, the perfusion test is repeated even after 1,000, 5,000, and 10,000 loads. Fluid flow studies for root canals have already been performed and published.

Biocompatibility studies:

Following the European Commission's EN 1441 Directive on Standardization, as with all newly developed dental materials, the final form selected on the basis of mechanical and preclinical tests is subjected to biocompatibility tests.

These are: primary studies, which include cytotoxicity and mutagenicity studies in cell cultures; secondary studies examining the effect of the mouth on microbes (Lactobacillus, Streptococcus) and tissue reactions induced by subcutaneous implants; use test to examine the oral resistance of fillings inserted in the teeth of experimental animals. This protocol was adopted in ISO (1984), Technical Report No. 7405.