Department of Operative Dentistry and Periodontology

Chair of Dental, Oral, and Maxillofacial Medicine – especially Operative Dentistry, Periodontology, and Pediatric Dentistry

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Research focus
- Clinical fractography on dental ceramic restorations
- Residual stresses and crystallization behavior in Lithium Disilicate glass-ceramics
- Tailoring of crystal alignment in glass-ceramic dental materials
- Measurement of mechanical properties and reliability
- Amalgam alternative restoration materials
- Material properties self-adhesive cements
- Polymerization properties of bulk-fill composites

Structure of the Department

Professorship: 1
Personnel: 50
- Doctors (of Medicine): 20
- Scientists: 4 (thereof funded externally: 2)
- Graduate students: 30

Clinical focus areas
- Restoration
- Endodontic treatment
- Systematic periodontal treatment
- Pediatric dentistry

Research

The main focus is on dental materials research with fields of expertise in basic science of operative and periodontal treatment procedures and correlation of experimental findings with clinical outcome. Independent, pre-clinical assessment of dental materials is a further area of interest of the laboratory section.

Clinical fractography on dental ceramic restorations

PI: Prof. Dr. U. Lohbauer, Dr. R. Belli

After the commercial launch of new dental ceramic materials, an increased incidence of intraoral fractures or chippings has been observed. The method of fractography is intended to clinically analyze failed dental restorations in order to assign relevant fracture mechanisms. In principle, fracture surfaces are intraorally replicated and macroscopically or microscopically investigated, using light or scanning electron microscopy. Specific fracture patterns thus provide information of involved failure mechanisms and respective reasons for failure. In a joint project with a German CAD/CAM milling center, approximately 1,000 failed restorations were fractographically examined and relevant reasons for failure were assessed. Based on the results originating from the Department of Operative Dentistry and Periodontology, a new nonprofit organization (Fracto Forum International e.V.) was founded. International workshops on dental fractography were already organized.

Residual stresses and crystallization behavior in Lithium Disilicate glass-ceramics

PI: Prof. Dr. U. Lohbauer, Dr. R. Belli

Classic ceramic materials in dentistry for inlays, partial crowns, and crowns were made out mainly of feldspathic glasses. These are highly esthetic, but deficient in mechanical properties. To provide for more mechanical durability, lithium disilicate glass-ceramics with high crystal fraction have been developed and gained wide popularity, with new materials being introduced in the market every year. However, the crystalline and the glass phases in such materials can suffer from incompatibility regarding their thermal behavior, resulting in weakening residual stresses in the glass. To overcome this problem, a deeper understanding of the crystallization behavior of lithium disilicate is necessary by tailoring the base glass composition. By performing controlled fracture tests, we gain insights on the fundamentals determining the resistance of such materials and are able to devise strategies to improve their damage tolerance.

Tailoring of crystal alignment in glass-ceramic dental materials

PI: Dr. R. Belli, Prof. Dr. U. Lohbauer

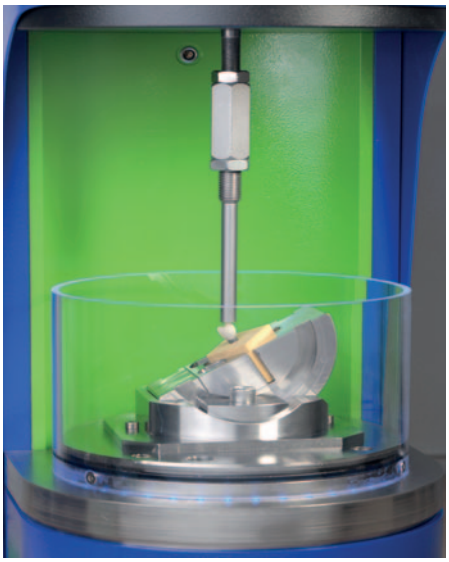
Most dental ceramics are produced from partially crystallized glass. Although these materials are hard, they are extremely susceptible to damage, especially due to the glass phase content. A strategy for strengthening these materials uses their microstructure to form reinforcing sites within the structural design. Such an approach has potential for application with lithium disilicate (LS2) glass-ceramics which contain needle-form Li2Si2O5 crystals that deflect oncoming cracks. By press injection of the glass melt through specifically oriented injection channels, crystals are aligned in patterns that lead to high mechanical anisotropy. In natural materials, like dental enamel, such effects take place through several length-scales through the hierarchical structural arrangement within the crystals and bulk. To grasp these mechanisms in LS2 dental ceramics in the macro-, micro-, and nano-scales, it is necessary to investigate specific material responses using state-of the-art mechanical testing.

Subtractive processing of a bilayered CAD/CAM dental bridge construct

Measurement of mechanical properties and reliability

PI: Dr. R. Belli, Prof. Dr. U. Lohbauer

Standardized measurements of mechanical properties help guiding materials development and serve as quality control for medical products being introduced into the market. Such mechanical tests must be controlled and conducted strictly according to international testing standards (i.e. DIN, ISO, ASTM). In the research laboratory for dental biomaterials we have worked on the constant improvement of our testing approaches to conform and validate testing standards. For that, we use standard reference materials and participate in inter-laboratory Round-Robin tests that provide means for improving the quality and sensitivity of testing procedures of dental materials.



Set-up for the fatigue testing of a polymer-infiltrated ceramic single crown over a titanium implant

Amalgam alternative restoration materials

PI: Prof. Dr. U. Lohbauer, Dr. R. Belli

Amalgam has been used in the past for treatment of small, carious defects in a wide, permanent, and insurance-covered manner. Adhesive polymer based materials are not sufficiently economical, while glass ionomer based materials do not provide sufficient strength potential for permanent supply. In the research laboratory for dental biomaterials, new materials are being investigated that meet the requirements of mechanical strength as well as cost-effectiveness without adhesive bonding and without light polymerization.

Material properties of self-adhesive cements

PI: Dr. J. Zorzin, Prof. Dr. U. Lohbauer

Self-adhesive cements enable the luting of indirect dental restorations without pretreatment of the tooth substrates. This is possible due to an acid-modified methacrylate-based chemistry. It is therefore of importance to investigate the material properties of self-adhesive cements (adhesion, strength, swelling, expansion stress) and influencing factors (pH neutralization, hydrophilicity, chemical composition).

Polymerization properties of "bulk-fill" composites

PI: PD Dr. M. Taschner, Dr. J. Zorzin

Direct conventional, light-curing, dental filling resin composites have a limited depth of cure and polymerization shrinkage. Thus, these materials must be placed in thin layers into the tooth cavity which is very time consuming. Modern „bulk-fill" composites claim to have a higher depth of cure and lower polymerization shrinkage. In the research laboratory for biomaterials, we investigate the polymerization properties of "bulk-fill" composites and make a parallel to conventional composite chemistry (degree of polymerization, hardness, shrinkage and shrinkage stress) up to how they influence the restored tooth cavity (marginal integrity and bond strength).

Teaching

The Department of Operative Dentistry and Periodontology is involved in the curricular teaching within the frame of the dental students' degree program. Interdisciplinary lectures are held at the Department of Materials Science and Engineering (Faculty of Engineering). In 2018, the Department of Operative Dentistry and Periodontology released a comprehensive text book for dental students entitled „Werkstoffkunde in der Zahnmedizin – Moderne Materialien und Technologien".

The Department offers supervision of Bachelor's and Master's theses as well as MD and PhD theses in conjunction with the Departments of Medical Engineering and Materials Science and Engineering.

Selected publications

Bitter K, Maletic A, Neumann K, Breschi L, Sterzenbach G, Taschner M. Adhesive Durability Inside the Root Canal Using Self-adhesive Resin Cements for Luting Fiber Posts. Oper Dent. 2017 Nov/Dec;42(6):E167-E176

Wendler M, Belli R, Schachtner M, Amberger G, Petschelt A, Fey T, Lohbauer U. Resistance curves of short-fiber reinforced methacrylate-based biomedical composites. Eng Fract Mech 2017;190:146-158

Lohbauer U, Scherrer SS, Della Bona A, Tholey M, van Noort R, Vichi A, Kelly JR, Cesar PF. ADM guidance-Ceramics: all-ceramic multilayer interfaces in dentistry. Dent Mater 2017;33:585-598

Belli R, Wendler M, Zorzin JI, Lohbauer U. Practical and theoretical considerations on the fracture toughness testing of dental restorative materials. Dent Mater 2018;34:97-119

Belli R, Wendler M, Cicconi MR, de Ligny D, Petschelt A, Werbach K, Peterlik H, Lohbauer U. Fracture anisotropy in texturized lithium disilicate glass-ceramics. J Non-Cryst Solids 2018;481:457-469

Belli R, Wendler M, Petschelt A, Lube T, Lohbauer U. Fracture toughness testing of biomedical ceramic-based materials using beams, plates and discs. J Eur Ceram Soc 2018;38:5533-5544

International cooperations

Prof. H. Peterlik, Institut für Physik, Universität Wien, Vienna: Austria

Prof. R. Danzer, Institut für Struktur- und Funktionskeramik, Montan Universität Leoben, Leoben: Austria

Prof. P. F. César, University of Sao Paulo, Sao Paulo: Brazil

Prof. S. Scherrer, University of Geneva, Geneva: Switzerland

Prof. Y. Zhang, University of New York, New York: USA