Abstracts

Oral implants made from zirconia ceramics. How do they perform?

Prof. Dr. Ralf Kohal, Medical Center - University of Freiburg, Center for Dental Medicine, Department of Prosthetic Dentistry

Zirconia oral implants are applied clinically meanwhile for many years and are a hot topic. This trend to use the zirconia implants is – among else - based on the constant material and system development and the request for ceramic implants is increasing. Preclinical (biomechanics, osseointegration) and clinical results are promising. Modern zirconia implants systems offer different treatment options (one-piece versus two-piece implants, cementation versus screw retention, etc.). The present lecture would like to elaborate among else on the clinical application of zirconia oral implants and present an update of the scientific background of zirconia implants. Clinical investigations on zirconia implants report comparable results to titanium implants up to 5 years. Furthermore, bone remodeling in the short and mid-term is comparable to the one seen around titanium implants. However, long-term results are currently missing to confirm the promising short- and mid-term data.

A prospective evaluation of self-glazed zirconia for posterior fixed dental prostheses: three-year clinical results

Per Tidehag

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Matching up the optical appearances of natural teeth and zirconia prostheses: interpretation and digitalization

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Dental ceramics have great advantage in optical appearances over other restorative materials, as their translucency, colour and shade are closest to those of the natural teeth. However, this superiority only reaches the level of “similarity” rather than “identity”, and the difficulty towards better performance lies in the matching-up in the details of translucency, colour and a balance between objective/scientific description of the colour and subjective feeling of the patients. In this report, two issues about optical appearances of the natural teeth and the zirconia prostheses will be discussed. Firstly, is it approachable to interpret the optical appearances using scientific terms quantitatively? That would involve the vital parameters, sections and special features in microstructure needed to be concerned when describing optical properties, and the reasonable measurement matching up conditions in practice with verification by modelling. Secondly, how to precisely transfer the information into the digitalized form and reasonably materializes it? Especially, we will explore some details of widely-used dental radiography that might be omitted but important in photography, and the possibility of great help from what have developed by smart image processing techniques.

Keywords: Optical properties; Teeth; Zirconia prostheses; Digitalization; Aesthetics

Adhesion to dental ceramics: techinical and clinical parameters

Prof. Mutlu Özcan

Durable adhesion of glassy matrix or oxide-based ceramics is crucial especially for minimally invasive reconstructions. This lecture will highlight the fundamental principles of adhesion to different ceramics, cover current knowledge and the clinical protocols regarding to surface conditioning methods and adhesion promoters to be used in conjunction with different resin-based materials duting luting or repair procedures.

Bonding of self-glazed zirconia prostheses with modifiedsurface topography in multiple micro and nanoscales

Prof. Kwok-Hung Chung
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Preparation of mullite toughened zirconia ceramics and the microstructure and mechanical properties

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Zirconia was widely used in clinical practice, driven by its physical, biological, esthetic, and corrosion properties. However, the risk of catastrophic fracture remains a concern. Incorporation of secondary phases into zirconia matrix was benefit for the fracture toughness. Mullite was the stable crystalline phase in the alumina-silicate system under normal atmospheric pressure with good properties, such as high melting point, low coefficient of thermal expansion, high chemical stability, high creep resistance and sufficient hardness. In this study, in-situ grown mullite toughened zirconia ceramics were fabricated by N,N-dimethyl acrylamide (DMAA)-based gel-casting. The effects of sintering temperature and the content of mullite on the microstructure and mechanical properties were investigated. The results indicated that the columnar mullite was evenly distributed in the zirconia matrix, the mechanical properties were improved because of pinning effect. 4% mullite-zirconia ceramics sintered at 1500°C had the optimum content and size of the columnar mullite phase, generating the excellent mechanical properties (the bend strength of 908.3 MPa, the fracture toughness of 10.0 MPa.m1/2, the Vickers hardness of 13.1 GPa). The synergistic effect of zirconia phase transformation toughening with mullite and alumina secondary toughening improved the mechanical properties of zirconia ceramics. Mullite-zirconia ceramic fabricated by gel-casting appears to be potential for applications as dental materials.

Keywords: Mullite-zirconia; Gel-casting; Mechanical properties; Toughening mechanism

References

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Why do we develop intelligent robots for oral surgeries?

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Towards reliable implementation of zirconia dental restorations

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Tetragonal zirconia polycrystalline ceramic partially-stabilised with 3 mol.% yttria (3Y-TZP) is regarded as an outstanding advanced structural ceramic material. Its high strength and toughness are achieved through the tetragonal-to-monoclinic (t-m) transformation toughening mechanism when the material is exposed to stress.
As such, 3Y-TZP ceramics are recognised as a potent option for all-ceramic dental restorations to comply with metal-free dentistry paradigm.There are, however still issues that need to be adressed. Firstly, when 3Y-TZP is exposed to moisture at slightly elevated temperatures the tetragonal grains on the surface start to spontaneously transform to the monoclinic phase. Due to the associated volume expansion, the process is accompanied by surface roughening, grain pull-outs and extensive microcracking, which may ultimately lead to strength degradation. The results from an ongoing in vivo clinical study will be presented and compared to the samples from an accelerated in vitro ageing experiment. In this way, for the first time, in vivo ageing results will be presented and, thus, it will be possible to make a real-time correlation of in vitro to in vivo results. Secondly, debonding may cause premature failures of the restorations. With the rise of the modern era of dentistry, where minimally invasive dentistry has become the norm reliable bonding of Y-TZP restorations is of even greater importance. The in-house developed adhesive coating will be presented ansd its clinical use demonstrated. A clinical study will be described, where the effectiveness of the coating is followed on 3Y-TZP inlay bridges (minimal invasive concept) cemented with adhesive or glass-ionomer luting cement. The simple application of adhesive coating has the potential of eliminating the need for the invasive and complicated step of APA and also turn back on using glass-ionomer cement, which is easier to handle but was inefficient for long-term 3Y-TZP bonding.
Keywords: zirconia ceramics; low temperature degradation; bonding

Novel Collaboration Cloud Platform for All-Digitalized Dental Restoration Manufacture

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Dental restoration manufacture involves close collaboration between multiple roles, like dentists, dental technicians and lab, with the help of kinds of tools, like design sheet, scanning data, models, etc. The collaboration will happen randomly, at any time, in any place and be highly customized. Moreover, the outcome of communication is decisive for the production effectivity and the quality of the restorations. Since the common restoration workflow has not been all-digitalized yet, information and data cannot be completely managed and well

organized, but just in some of period. However, a new kind of all-ceramic restorations, named as Self-Glazed Zirconia Restorations ("SGZ" for short), which are produced by intelligent manufacturing process, enable that the whole restoration workflow could be all-digitalized and therefore the collaboration between multiple roles could be redefined.
Benefit from cloud service, which has advantages of effective computing, mass storage and real-time communication, we developed a novel multiple roles collaboration cloud platform for all-digitalized dental restoration manufacture. This cloud platform is browser-based, and completely covers the whole restoration workflow, including data transfer, denture design, design review, real-time communication, manufacture, after-sales service, statistics, cost settlement, etc.

Based on the characteristics of the novel dental restorations like SGZ, which is produced through intelligent manufacture process and no clinical adjustment is needed, we creatively separated the design and the manufacture into two independent parts, and introduced special "Design Center" and "Free Designer" into the workflow. Multiple roles collaborate closely on this cloud platform. Dentists only need to submit digital models and customized restorative requirements to the cloud platform, registered dental designer will be informed automatically and finish the design task timely, then upload the design document to the cloud platform, from which intelligent manufacture center can download and produce the dental restorations. A highly efficient and convenient ecosystem is then formed. This innovation liberates the highly dependence of manufacturers on the qualified designers to the maximum extent, and realizes the global collaboration, thereby improving the quality of dentures and better serving dentists and patients.

Keywords: dental restorations; collaboration; cloud platform

Parameters optimization for CAD-CAM machining of zirconia

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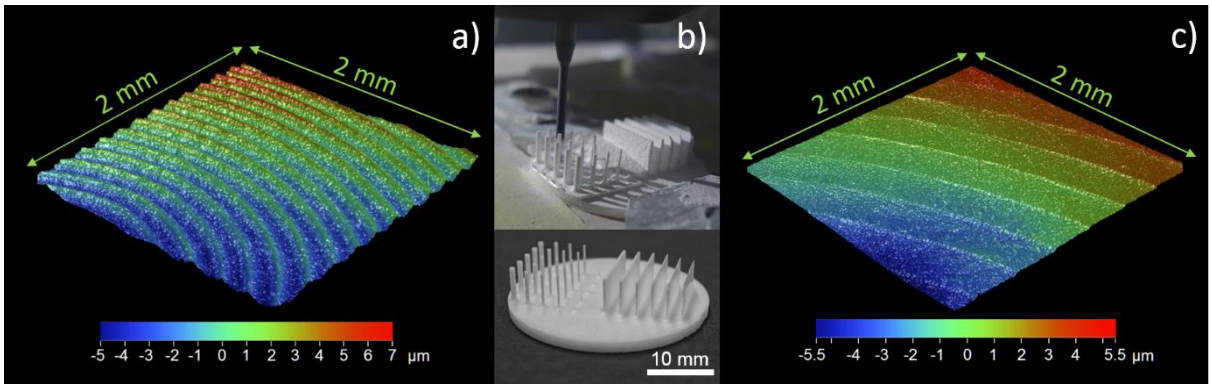
CAD-CAM producing technology and CNC machining of ceramics are used in dentistry for many years and it starts to be used in other applications as well. There are several methods for ceramic blanks production and gelcasting represents one of the promising method. Benefits of the gelcasting are the complex-shaped blank preparation, more homogeneous structure of the blanks, machining without pre-sintering treatment and their isotropic shrinkage during sintering. Zirconia blanks were prepared by the gelcasting and machined before sintering using two types of the machining tools – a ball end mill and a flat end mill. Various machining parameters (depth and width of cut, machining strategy) as well as various pre-sintering heat treatments were investigated and optimized. Shrinkage, shape accuracy, edge sharpness, surface roughness and the flexural strength by the ball-on-three-balls test (B3B) of sintered zirconia samples were evaluated. Lamellae and pins were successfully machined. The thinnest thickness of sintered lamella was 80 µm and the smallest diameter of sintered pin was 320 µm Although the surface roughness (Ra, Rv, Rp, Rz) of machined zirconia discs by ball and flat end diamond mills was significantly different, the flexural strength was almost the same.



Abstract figure a) surface profile after sintering of zirconia disc machined by ball end mill, b) machining process and sintered zirconia part, c) surface profile after sintering of zirconia disc machined by flat end mill.

Keywords: CAD-CAM; machining; zirconia; surface roughness; flexural strength

Chemical Vapor Deposition of Bio-Ceramic Coating

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Titanium (Ti) and its alloys are reliable for use as biomaterials due to their strength, ductility and durability in the human body; however, the tissue compatibility of metallic biomaterials is insufficient for biomedical applications. Although the microstructure and phase of metallic materials are generally well-controlled by thermomechanical treatment in order to satisfy the mechanical properties required for biomedical applications, tissue compatibility should be improved while maintaining the microstructure and mechanical properties of these materials. The surface modification, in particular bio-ceramic coating by chemical vapor deposition (CVD), is a promising way to improve the tissue compatibility of biomaterials, and CVD can construct functionally graded structure by changing deposition conditions, which could be the ideal structure between ceramic coating and tissue of the human body.

CVD has advantages of good conformal coverage and morphology control. Common CVD (thermal CVD) generally needs high-temperature to implement coating, while the degradation of metal substrate should be minimized. Plasma-enhanced CVD (PE-CVD) can coat wide-area substrate uniformly with low temperature deposition. Laser CVD (LCVD) was used to prepare whiskers, nano-dots and thin film semiconductors, however LCVD has never been employed for wide-area thick and high-speed coating. We have developed various CVDs, i.e., thermal CVD, PE-CVD and LCVD, to optimizing microstructure of bio-ceramic coating enabling low-temperature and high-speed deposition. Hydroxyapatite (HAp, $Ca_{10}(PO_4)_6(OH)_2$), α-tricalcium phosphate (α-TCP, α-$Ca_3(PO_4)_2$) and β-tricalcium phosphate (β-TCP, β-$Ca_3(PO_4)_2$) films have been prepared by CVD, and α-TCP and HAp films in a single phase and mixtures of α-TCP and HAp were obtained by controlling CVD conditions. The microstructure and orientation are decisive chatacteristics for the regeneration of HAp on the coated CP-Ti. The HAp films had a significant preferred (002) orientation. The deposition rate of HAp depended on deposition conditions showing a maximum value of 22 μm h^{-1}, about 10 times grater than that of common sputtering. The HAp coated CP-Ti after the immersion in the Hanks' solution was covered by HAp after 6 hours. Since HAp regeneration on Ti usually needs 4 to 6 weeks, the (002) oriented

HAp coating prepared by CVD can be good candidate for the bio-ceramic coating. The functionally garded structure from $CaTiO_3$ to HAp film was prepared by CVD, realizing strong bonding to CP-Ti by $CaTiO_3$ and good biocompatubility by HAp coating.
Although Ca-P-O system films have been commonly investigated for the bio-ceramic coating, we have been seaching alternate candidateds by CVD. Ca-based compounds can be candidate, and we found that $CaSiO_3$, Ca_2SiO_4, $CaTiO_3$, pyrochlore $Ca_2Ti_2O_6$ and Ruddlesden-Popper $Ca_4Ti_3O_{10}$ films are promising bio-active ceramic coatings. In particular, the $Ca_4Ti_3O_{10}$ film was formed by LCVD with cauliflower-like morphology beneficial for the bone regeneration. The deposition rates were 100-230 μm h^{-1}, which were 20 times higher than those by thermal CVD. By immersion in the Hanks' solution, HAp formed significantly on the $Ca_4Ti_3O_{10}$ film, compared to the $CaTiO_3$ and $Ca_2Ti_2O_6$ films.
Keywords: CVD, Hydroxyapatite, Tricalcium phosphate, Calcium titanate

Dimension Accuracy and Clinical Adaptation of Ceramic Crowns Fabricated by Stereolithography Technique

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Purpose: To evaluate the dimension accuracy and clinical adaptation of ceramic crowns fabricated by stereolithography technique.
Methods: 10 ceramic crowns were fabricated by two different stereolithography systems (CeraFab and CSL) and a conventional CAD/CAM system (X-CERA). First, crowns were scanned and digital models were exported. Dimension accuracy was measured by superimposing the digital models with the reference model using Geomagic Qualify. Then, a silicon replica method was applied to measure the clinical adaptation. Results were statistically analyzed using one-way ANOVA test(α=0.05).
Results: The CeraFab showed the best dimension accuracy (40.8±10.6μm), followed by CSL (64.5±5.9μm) and X-CERA (71.7±13.3μm). CSL and X-CERA showed no significant difference(p=0.287), whereas CeraFab and CSL, CeraFab and X-CERA exhibited statistically significant differences(p<0.05). Crowns fabricated by X-CERA showed significantly better adaptation on marginal (61.90±8.96μm), corner(60.07±6.32μm), occlusal(27.61±5.44μm) area but inferior adaptation on axial area(131.22±4.72μm) than CeraFab (marginal: 92.55±31.80μm, corner: 114.51±29.81μm, occlusal: 209.95±32.05μm, axial: 54.82±9.13μm) and CSL (marginal: 109.33±26.79μm, corner: 97.64±29.37μm, occlusal: 149.12±45.75μm, axial: 70.64±14.97μm)(p<0.05). While significant differences can only be found in on the axial and occlusal area between CeraFab and CSL(p<0.05).
Conclusions: The CeraFab system showed significantly better dimension accuracy than X-CERA system, whereas the CSL system showed no significant difference in dimension accuracy with X-CERA system. Both CeraFab and CSL system can provide clinically acceptable adaptation. The results indicate that applying stereolithography technique in fabricating ceramic crowns seems promising.
Keywords: Stereolithography; Ceramic crown; Accuracy; Adaptation

Minimising defects in zirconia dental prostheses by stereolithography-based additive manufacturing: focusing on the post printing processes

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Stereolithography technique is considered to be a promising way to fabricate ceramic dental prostheses in a materials-saving manner. Although this technique has developed rapidly and proven itself capable in shaping the macrostructure of printed parts, optimizing microstructure, especially minimizing defects through post-processing remains still as hard tasks. In this work, dental implants, crowns and bridges were printed by stereolithography-based method using zirconia slurry. Relative density, shrinkage rate, flexural strength of the debound and sintered ceramic parts were characterized, so do the structural defects, such as scratches caused by support structure and delamination between layers, to evaluate the influencing factors. TG-DSC was utilized as a guide tool to optimise parameters for post printing heat treatment process in order to obtain zirconia parts with less delamination. Further improvement in dimensional accuracy, shape fidelity and surface quality would depend on the optimization of processing parameters of printing and post printing heat treatment processes as well as the design of the support structure.

Keywords: additive manufacturing, stereolithography, post processing; defects; dental ceramics

Ten reasons for pursuing zirconia implants

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Evaluating the fatigue performance of zirconia dental implants

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Dental implants are a widely accepted solution for edentulous people to whom masticatory functions must be restored. To date, most of the emphasis has been put on *clinical issues* related to the implant and the implantation process, while the *mechanical reliability* of those bio-structures has been most often overlooked or taken for granted.

Time has come for a rigorous engineering evaluation of this issue so that not only the implant design, but also its performance can be known and specified.

With that in mind, we will introduce the random spectrum fatigue testing approach, in which randomly selected loads are applied at random frequencies to somewhat mimic mastication and provide readily an evaluation of the functional performance of the group of implants under investigation, in the spirit of structural testing of aeronautical components.

We will report a systematic evaluation of the fatigue functional performance of dental implants made of partially stabilized zirconia (Y-TZP), using random spectrum fatigue testing in both air and 0.9% saline solution.

This study reveals that saline solution reduces the static fracture strength of the zirconia implants. It also causes a marked degradation of their spectrum fatigue longevity, but does not affect their spectrum fatigue fracture strength.
The results of those tests suggest maximum admissible design loads for spectrum loaded zirconia dental implants that are of the order of 0.8 times their wet (saline or other) static fracture strength.
The mechanical results will be presented along with a detailed electron fractographic analysis, thereby providing some guidelines for performing future failure analyses of in-vivo fractures of ceramic implants.
It is expected that the approach presented here will motivate further re-assessment of dental implant design, manufacturing and ultimately usage.
Keywords: dental implants, zirconia, random spectrum, fatigue, air, saline solution

Self-glazed Zirconia for anterior Esthetic Restorations

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Monolithic zirconia restoration is an acceptable treatment option in restorative dentistry and a developing trend in esthetic dentistry. Digital dentistry has simplified fabrication of monolithic zirconia restorations. Self-glazed zirconia represent a new category of monolithic ceramic restorations with functionally tailored hierarchical structures exhibiting superior smoothness on occlusal surface formed spontaneously during the net-shape manufacturing process that imitates the function and optical appearances of the natural tooth enamel. however, difficulties to gain an optimal shade reproduction and a color match with monolithic zirconia restorations still remain.This case report describes three clinical examples of monolithic self glazed zirconia fixed dental prostheses being used in the anteriorregions and exhibiting acceptable esthetic results. Combined with CAD/CAM technology, monolithic self-glazed zirconia enables the fabrication of esthetic all-ceramic restorations in all areas of the mouth.

Optical and mechanical properties of novel zirconia

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Purpose: The purpose of this in vitro study was to assess and compare the translucency and flexural strength of two kind of novel zirconia.
Materials and methods: Group 1(high-translucent zircoina): Lava™ Plus(3M), X-CERA ST(X-CERA), SHTC(Aidite); group 2(ultra-translucent zirconia): Lava™ Esthetic(3M), X-CERA SHT(Xiang Tong), Xuancai AT(Aidite); group 3(lithium disilicate):UP.CAD(Upcera). 126 disk-shaped specimens of 7 mm diameter and 3 levels of thickness(0.5mm, 1.0mm, 1.5mm, n=6) were prepared. 90 bar-shaped specimens were prepared with dimensions of 25mm x 4mm x 1.2 mm(n=15). A spectrophotometer was used to measure the translucency parameter. The flexural strength of the specimens was determined by using a 3-point bending test. Data wre analyzed using one-way ANOVA and SNK test(α=0.01).
Results: Significant differences were found among the materials concerning translucency and flexural strength($P<0.01$). 1.The highest mean translucency value was obtained in the UP.CAD

group. No statistical differences was found between SHTC and Xuancai AT at the thickness of 0.5mm or 1.0mm, while the transluceny of Xuancai AT was superior to that of SHTC at the thickness of 1.5mm. The transluceny of Lava™ esthetic was superior to that of Lava™ at every level of thickness as well as X-CERA SHT to X-CERA ST. Among the 0.5mm specimens, SHTC, Lava™ esthetic and Xuancai AT produced the highest translucency value of their group. Among the 1.0mm specimens, X-CERA ST, X-CERA SHT and Lava™ esthetic produced the highest translucency value of their group. Among the 1.5mm specimens, X-CERA ST and X-CERA SHT produced the highest translucency value of their group. 2. The mean flexural strength of ultra-translucent group was superior to high-translucent one with the same brand. The highest mean flexural strength was obtained in X-CERA ST and X-CERA SHT of their group.

Conclusions: 1. The mean translucency value of ultra-transparent zirconia was not inferior to that of high-translucent with the same brand, and the difference was related to the thickness. 2. Glass-ceramics produced the highest translucency value. 3. The mean flexural strength of high-translucent zirconia was significantly superior to that of ultra-translucent, both of which were more than 300MPa.

From Dentistry to orthopedics: a consistent struggle for better precision and materials

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A paradigm shift in dental ceramics

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Dental ecosystem in digital era

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Bioactive Silicon Nitride Dental Implant

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Titanium and its alloys are still the “gold” materials for dental implants. However, there is an increasing demand for metal-free dental restorations, which leads to the development of ceramic-based dental implants, such as zirconia. Except zirconia, in orthopaedics, another ceramic, silicon nitride, has been used as spinal implant and for joint replacement. Silicon nitride ceramics has been shown to have potential antibacterial properties besides their good mechanical strength. Regarding the dental implantology applications, a good osseointegration is needed. An improvement of silicon nitride bioactivity could be essential to increase the osseointegration capability of the material. Our strategy is to add bioactive ions, such as Mg, Sr and Si, in silicon nitride ceramics. The aim of this study was to increase its bioactivity

without sacrificing the mechanical strength and antibacterial properties. The new Si3N4 ceramics were sintered by SPS, followed by the analyses of mechanical strength, ion release, bioactivity, cytotoxicity, and antibacterial properties. The results were promising, and the bioactive silicon nitride ceramic could be of great interest for the use as dental implants.

Micro-to-nano roughening of 3Y-TZP surface for improved osseointegration and antibacterial response

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Titanium implants are widely used in prosthetic dentistry, but the increasing medical and aesthetical concerns regarding peri-implantitis and gingiva discolouration, respectively, have set zirconia-based (3Y-TZP) ceramics exhibiting superior biocompatibility and whitish appearance as an all-ceramic, metal-free alternative. The bone tissue response can be enhanced if the micro- and nano-roughening of the surface are provided. The first one is achieved by gentle sandblasting, which also improves strength and ageing resistance of 3Y-TZP, and is readily adopted in everyday dental laboratory practice. However, nano-roughening can only be achieved by complex nanostructures deposition and/or aggressive acid etching, where the latter is problematic due to the brittle nature of ceramics and potential differential cation dissolution affecting ageing stability.

The aim of presented work was to employ a simple, non-invasive, additive approach for the nano-roughening of micro-roughened 3Y-TZP surfaces, achieved by sandblasting, by the application of a nanostructured alumina coating. As-modified surfaces were characterised regarding their morphology and phase composition, roughness, wetting behaviour, and zeta potential and correlated to the behaviour of human osteoblast cells and Staphylococcus aureus bacteria. The combination of micro- and nano-roughening was beneficial for initial cell attachment and differentiation while exhibiting increased antibacterial properties by either limiting bacterial adhesion or by killing a significant proportion of the attached bacteria. The presented strategy that is already available in dental laboratories could represent a feasible and effective solution for modifying the surfaces of 3Y-TZP dental implants, improving their osseointegration and antibacterial properties.

Monolithic Zirconia Ceramic Dental Prostheses – Clinical Experience

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Due to the extremely rapid development of dental materials, the industry offers new types of dental ceramics. The development of dental ceramics follows the introduction of new mainly computer-controlled dental laboratory technologies and new clinical indications.

New generations of glass ceramics and zirconia ceramics allow today completely non-metallic fixed prosthetic rehabilitations. Their implementation in a monolithic form is increasingly used to avoid technical complications. In addition, with the use of monolithic form, the laboratory production process is simplified, the abutment teeth reduction is minimized and the material is more homogenous.
Monolithic zirconia has been comprehensively evaluated in *in vitro* studies but limited clinical evidence is available on their longevity and reliability. The results of *in vitro* studies may not fully reflect the clinical performance of the materials due to the complexity of the oral environment, therefore clinical performance cannot be directly predicted from laboratory tests. The aim of the current clinical study is to evaluate the clinical performance of multi-unit monolithic zirconia FDPs in higher load-bearing areas of dental arches.
A total of 20 patients (mean age: 58.7±10.2 years old) in need of posterior maxillary or mandibular multi-unit FDPs milled from translucent zirconia blanks and sintered at a 1510 C for 2 h were included in the study. Aesthetic qualities and functional performance of restorations were evaluated with modified Ryge criteria.
The survival rate of multi-unit monolithic zirconia FDPs observed in our 2.5 years clinical study was 96.9%. No chipping, debonding or fracture was observed, only one FDP had to be replaced, due to biologic complications of the abutment teeth and some patients presented decreased performance as regards to periodontal parameters. Considering short observation time, the monolithic zirconia FDPs are an appropriate treatment option for prosthetic rehabilitation in the posterior region. They exhibited excellent mechanical properties, good marginal stability and are well accepted among patients.
Keywords: zirconia; ceramics; monolithic; dentistry.

Spectrophotometric examination of multilayered zirconia

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Background: Research had been carried out on the optical effects of different monotithic zirconia. The analysis of the results established the idea for further studies on multilayered specimens to find out whether such materials behave differently. Objective: The aim of this in vitro study is to examine the optical effects of multilayered and coloured monolithic zirconia of different thickness, combined with substrates of different colours. Such combination can be simulated using the world's most advanced spectrophotometer. Materials and methods: Multilayered zirconia specimens were used for the study with the thickness range of 0.5- 2.5mm as well as 3 try-in pastes (Variolink Esthetic) and 6 types of substrate materials (VITA Simulate) and three types of metal substrates. Measurements were done at the Optic Laboratory of the Faculty of Atomic Physics of Budapest Technical University with a PerkinElmer® Lambda 1050 UV/Vis/NIR spectrophotometer, measuring the reflection spectrum by which the L*a*b values were calculated and compared to the reference (ΔE). Calculations were based on the CIEDE2000 formula. Results: The colouring of multilayered zirconia also has a major effect on ΔE values resulting in different colour perceptibility and acceptability. Such values are however higher than those of the previously examined monochromatic specimens. Try-in pastes have no significant effects overall. Conclusion: In general the application of coloured zirconia is eligible for the preparation of aesthetic crowns due to their substrate-covering effect.

Nonetheless it is an interesting phenomenon that the multilayered specimens showed different results than those of the A2 specimens. In order to get an explanation the structure and optical behaviour of multilayered zirconia needs further examination.
Keywords: Multilayered zirconia; spectrophotometric analysis; reflection; monolithic zirconia; colour

Posters

Morphological changes of pharyngeal airway after incisor retraction in bimaxillary protrusion growing patients with maximum anchorage

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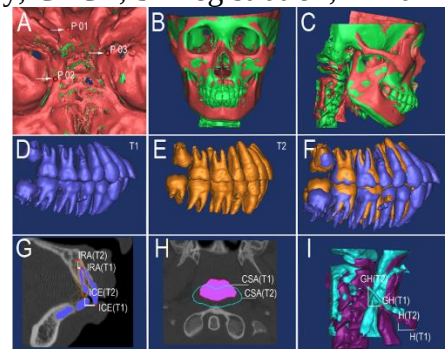
To evaluate the changes of morphology in the pharyngeal airway after incisor retraction in bimaxillary protrusion growing patients with maximum anchorage by three-dimensional（3D）registration and evaluation. Cone beam computed tomography (CBCT) scans of 32 growing patients with bimaxillary protrusion and 32 age- and gender- matched controls were reconstructed. A student t-test was used to compare morphological changes of pharyngeal airway between two groups.After treatment, both groups showed a general enlargement in pharyngeal airway dimensions. There showed no statistical differences in the change of pharyngeal volume, CSA, LAT/AP and GH between the two groups. However, the experiments showed a significant decrease in the ration of palatopharynx area (PPA) to glossopharynx area (GPA) compared with the control group. A significant correlation was observed among the PPA/GPA，the incisor retraction amount and the hyoid backward amount. Growing bimaxillary protrusion patients with maximum anchorage showed a potential trend of slower growing speed of palatopharynx than glossopharynx, which may be caused by the backward of the hyoid and retraction of the central incisor.Please type your abstract here; Use Times New
Keywords: Pharyngeal airway; CBCT; 3D registration; Bimaxillary protrusion



Expression and Function of Hypoxia Inducible Factor-1α and Vascular Endothelial Growth Factor in Rat Periodontal ligament under Orthodontic Stretch

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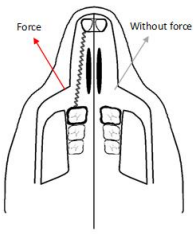
Orthodontic tooth movement is considered as a biological response to the orthodontic stretch via the osteoblast and osteoclast processes. Orthodontic stretch leads to strain in the periodontal ligament, circulatory disturbances, and vascular changes of the periodontal tissue, which cause a hypoxic environment in local tissue. However, bone remodelling is not only induced by mechanical stress but also effected by hypoxic environment which regulated by numerous factors. Thus, we established a rat model of orthodontic tooth movement to investigate the expression and function of HIF-1α and VEGF in rat periodontal ligament under orthodontic stretch. The results showed that osteogenesis and vascular changes occurred in the tension site of alveolar bone during orthodontic tooth movement. Additionally, there were significant changes in the expression of HIF-1α and VEGF proteins under orthodontic force. Compared with control group, experimental group expressed significantly more HIF-1α and VEGF protein on the surface of the alveolar bone tension side during the rat tooth movement ($P<0.05$). These data showed that the hypoxic environment could be induced by mechanical force. HIF-1α and VEGF may play an important role in maintaining the physiologic equilibrium of periodontal tissue reconstruction during orthodontic tooth movement.

Keywords: HIF-1α; Orthodontic Stretch; Immunohistochemistry



Fabrication of implant-supported cross-arch fixed bridge with titanium framework and all-ceramic crowns

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Process:
A case of male patient with dentition defect in maxilla is presented. The treatment design was rehabilitation of maxillae of dentition defect with all-ceramic crowns and cross-arch titanium framework.
A set of commercial artificial teeth was selected according to the patient's gender, age, and the shape of face, for the immediate loading provisional prosthesis. Six month later, after the satisfatory confirmation of the esthetic and function by both the patient an the prosthodontist, a copy of the denture was made of the pattern resin. The replica was adjusted for the remodeling soft tissue conjunction. It was cut back for the shape of the framework. The titanium framework was manufactured using CAD/CAM technology. After the abutments on the framework was scanned, individual all-ceramic crowns were designed and milled with the same CAD/CAM system. The artificial gingiva part of the framework was fabricated with light-curing resin.
Keywords: implant supported, CAD/CAM, titanium frame, all-ceramic crowns

In-vivo aged phosphate cements tells the stories

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The bonding between the crown and natural tooth or implant abutment is an important factor to the reliability of the dental restorations. Problems in the interface may nourish bacterial growth and jeopardize the stability of the restorations. In this study the chemical composition, phase assemblages and the microstructure of the intraoral aged two phosphate cements were investigated. The characterized samples were those teeth with cemented prostheses lasted intraorally for 6-25 years where some of them had to be clinically extracted due to sever periodontal diseases. Four different crown materials, namely Au, Co-Cr, Al2O3-SiO2, Ni-Cr-Mo were encountered. Large pores were observed in zinc phosphate cement with the growth of platelet tertiary zinc phosphate (hopeite) crystals inside as a clear indication of aging. Cracking and loss of cement at the marginal end of the cementation were observed in bonding gaps filled with both calcium and zinc phosphate cements. The dissolution of unreacted zinc oxide particles was also seen close to the margin side of the bonding gap. Interfacial cracks were observed in all the samples characterized, that were concentrated at the cement-tooth interface in case of zinc phosphate cement bonded crown, whereas at the cement-crown interface in case of calcium phopshate cement bonded crown. Carbon was detected along the cracks and reach up to the restoration top, which may indicates the penetration of protein-containing saliva or possibly even bacteria. The clinic implication and the inspiration of these observations for future cement development will be discussed.

Method to accuracy control when three-dimensionally ablating dental sintered zirconia with numerically controlled femtosecond laser

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The quantitative relationships between the number of focal-plane additive pulse layers(n)in two-dimensional ablations, the Z-axis feed rate, and the ablation depth (d)during sintered zirconia ablation using a numerically controlled 3-axis femtosecond laser are studied, and appropriate methods for precise ablation control are established. Two-dimensional ablation is performed on sintered zirconia in the focal plane on a preset circular path using a femtosecond laser device and an in-house-developed 3-axis numerically controlled micro laser galvanometer scanner. Hence, the quantitative relationship between n and d are obtained. The measured and theoretical values of the ablated cavities are compared to obtain n and d values corresponding to the minimum difference, and to evaluate the error in d; hence, a higher-accuracy d value (i.e., single-step ablation depth) is obtained. Each sample underwent three-dimensional scanning and ablation to produce cylinders. The overall errors between the measured and design data for 24 cylinders were controlled within 10 μm. Thus, high-quality sintered zirconia ablation can be achieved using a femtosecond laser with the parameters employed in this study. Precise control of the sintered zirconia laser d can be attained by optimising the single-step ablation parameters. This lays the foundation in the production of sintered zirconia restorations using femtosecond laser.

Keywords: femtosecond laser; sintered zirconia; accuracy ablation

A porous microsphere based on PLGA for dentin-pulp regeneration

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Tissue engineering technology provides a new approach to achieve pulp-dentin regeneration. Stem cell, growth factors and scaffolds are three essential elements in the tissue engineering. Based on the principles of tissue engineering, the scaffold could direct the cell differentiation and angiogenesis. The geometrical design of porous scaffolds used for bone tissue engineering has been proved to significantly influence the cellular response and the efficiency of bone tissue regeneration. The influence of geometrical design of the porous scaffolds such as surface curvature, pore shape, and pore size on bone tissue regeneration has been studied. It has been shown that concave surfaces curvature is more beneficial for the bone tissue generation compared with the convex and planar surfaces. The purpose of this study was to develop a novel tissue engineering scaffolds for dental pulp regeneration with specific geometrical design on the surface curvature, pore shape and pore size. The porous microsphere composed of poly (lactic-co-glycolic acid)/β-tricalcium phosphate/Nano-silicon was prepared by water/oil/water(w/o/w) double emulsification method with porogen. The suitable concentrations of the three compositions were selected contribute to the uniform size of the porous microsphere. Series of tests were performed to access the physicochemical properties

and the biological properties of the novel PLGA / β –TCP/Nano-silicon porous microsphere.
Acknowledgment: This study was supported by grants from the Natural Science Foundation of China (Project nos. 51772007).
Keywords: Porous microsphere; Nano-silicon; Human dental pulp cell

Antagonist Enamel Wear of Self-glazed Zirconia Crowns In Vivo

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The purpose of this study was to test the hypothesis that there is no difference in the in vivo wear of enamel opposing self-glazed zirconia crowns and enamel opposing natural teeth. Patients requiring full molar crowns received self-glazed zirconia crowns. The contralateral opposing molars were identified to serve as enamel controls. After crown cementation, impressions of jaws were obtained and poured in stone for baseline data. Patients were recalled at one-year for re-impression. Stone models were scanned using a tabletop laser scanner to determine mean vertical loss of the occlusal contact areas. Statistical analysis was performed using t-tests to determine any significant differences between the wear of enamel against self-glazed zirconia crowns and natural teeth. Thirty five self-glazed zirconia crowns were delivered. Mean vertical loss was 33.4 μm for the enamel opposing self-glazed zirconia crowns and 29.9 μm for the contralateral antagonists. There were no statistical differences in mean vertical loss of the two groups ($p > 0.1$) after one year. Self-glazed zirconia crowns exhibited comparable wear of enamel compared with control natural teeth after one year. Clinical application of self-glazed zirconia is recommended with regard to wear behavior, because the amount of antagonistic enamel wear after 1 year is comparable with that caused by contralateral natural antagonists in this study.
Keywords: self-glazed zirconia; enamel wear; ceramic crown

Ceramics solutions towards digital dentistry

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The effect of firing protocols on the resin-bond strength to alumina-coated zirconia ceramics

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Surface pre-treatment of the bonding surface of zirconia ceramic dental restorations with a nanostructured alumina coating (NAC) establishes a substantially stronger and durable bond than clinically established subtractive procedure of air-particle abrasion. However, it is crucial to integrate the synthesis of NAC to completely comply with everyday dental laboratory practices.

In the present study, the effect of various dental laboratory firing procedures, such as glaze, veneer and regeneration firings of zirconia that usually take place between 725 and 1050°C, on the temperature-dependent phase evolution of NAC was studied and related to the resin cement shear bond strength provided by commonly used zirconia surface treatments. For comparison as-sintered, high-pressure (4 bar) and low-pressure (1 bar) air-particle-abraded zirconia surfaces with or without a combination of MDP primer were tested. Half of each sample groups (n=20) were subjected to 12000x thermocycles in water between 5 and 55°C. NAC`s morphology was analysed using SEM, while XRD was used to assess NAC phase evolution during firing procedures. For statistical analysis T-test and one-way ANOVA were used. The results show that when the NAC was fired at 900 and 1050°C and topotactically transformed to γ- or a mixture of δ- and θ-aluminas, it provided highest and clinically acceptable bond-strengths (>20Mpa) not affected by thermocycling.

Keywords:*:* Zirconia ceramics; shear bond strength; nanostructured alumina coating; laboratory firing protocols