

EVALUATION OF ACCURACY AND PRECISION OF DENTAL CROWNS 3D PRINTED AT DIFFERENT ANGULATIONS

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Aim: to evaluate the accuracy and precision of crowns 3D printed with different angulations in terms of fidelity to the digitally designed crown (accuracy), repeatability of the print (precision) marginal accuracy and occlusal surface quality.

Methods: an artificial molar was prepared to receive a full crown and scanned using an intraoral scanner. The crown was designed using a dedicated software, then printed using a commercial 3D DLP printer and a dental resin. A total of 15 resin crowns were printed with an axis angulation of either 90°, 135° or with a Custom angulation for which fewer printing supports were needed (5 crowns for each group). The crowns were then scanned and compared to the original 3D model for accuracy and among themselves for precision using a speciali-

zed software. The marginal accuracy and occlusal surfaces were then evaluated macroscopically.

Results: 3D printed resin crowns printed using a 90° angulation show a higher fidelity to the digital model (accuracy) compared to other angulations only in the internal aspect of the crown: for the occlusal aspect, Custom angulation crowns were better. Custom Crowns also showed a higher repeatability of the print (precision) regarding the internal aspect and were equal to 90° crowns regarding occlusal aspect. 135° performed equal or worse in all aspects for both precision and accuracy.

Conclusions: from a clinical standpoint, Custom angulation crowns might represent an optimal solution for both internal and occlusal results for 3D printed provisional crowns, in terms of fidelity to the digital model and print repeatability.

BONDING EFFECTIVENESS OF A COMMERCIAL DENTAL ADHESIVE SYSTEM CONTAINING EXPERIMENTAL QAMS

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Aim: this study aimed at investigating the bond strength of a commercial 3 steps E&R adhesive containing experimental antibacterial quaternary ammonium dimethacrylate monomers (QAMs) designed and synthesized in our research laboratory (Italian patent n° 102019000020949, publication date 20.10.2021). The null hypothesis was that the microtensile bond strength (μ TBS) was not affected by the antibacterial QAMs.

Methods: four patented experimental antibacterial QAMs (Q1, Q2, Q3, Q4) were used for this study. Fifty extracted non-carious human third molars were selected for the study. The teeth were cut to expose middle/deep dentin and assigned to one of the following groups: (1) E&R (Adper Scotchbond Multi-Purpose, 3M ESPE), (2) E&R+1%Q1, (3) E&R+1%Q2, (4) E&R+1%Q3, (5) E&R+1%Q4. Specimens were processed for

μ TBS test following the non-trimming technique and μ TBS was performed after 24h of storage in artificial saliva at 37°C. Groups were statistically pairwise compared with the non-parametric Kruskal-Wallis test ($\alpha = 0.05$).

Results: only group 5 showed a statistically significant decrease in the bond strength of the adhesive when compared to the other groups ($p < 0.05$). The presence of the QAMs did not affect bond strength in the other four groups, which exhibited similar bond strength values ($p > 0.05$).

Conclusions: the null hypothesis was partially rejected because a statistically significant decrease of μ TBS was observed for group 5. Further studies with different aging conditions of the adhesive interface will be performed to assess the long-term behavior of the experimental QAMs.

COMPARATIVE ANALYSES OF THE REMINERALIZATION EFFECT OF DIFFERENT REMINERALIZING AGENTS ON ENAMEL

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Aim: this study aimed to compare qualitatively and quantitatively the remineralizing effect of four commercially available remineralizing agents on artificial enamel lesions using Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS).

Methods: twenty-four extracted third molars were collected and randomly assigned to six groups (n = 4): Control Group (CG), without treatment; Negative Group (NG), treated with a demineralizing solution; Mousse Group (MG), treated with a mousse of casein phosphopeptide and amorphous-calcium-phosphate (ACP), associated with 0.33% sodium monofluorophosphate; Nano-hydroxyapatite Group (N-HAG), treated with a gel containing zinc-hydroxyapatite; Duraphat Group (DG), treated with a 5% sodium fluoride varnish; Biosmalto Group (BG) treated with a dentifrice containing ACP functionalized with fluoride and carbonate-coated with citrate. Except for

CG, all groups were suspended in demineralizing solution for 72h in order to create artificial enamel lesions. Then, each sample was treated for 28 days with the assigned remineralizing agent, following the product's instructions. The pH cycle (demineralization-remineralization) was used to simulate the oral pH fluctuation patterns. Analyses of the specimens' enamel surfaces morphology were performed by SEM and EDS. Data were statistically analyzed for multiple group comparison by one-way ANOVA/Tukey's test ($p < 0.05$).

Results: scanning electron micrographs showed that MG, N-HAG, DG and BG had significantly higher amount of remineralization than group NG. Regarding the Ca/P ratio, the NG was statistically different from other groups, while all tested groups showed no differences with the CG.

Conclusions: this study concluded that all groups tested showed improved surface remineralization.

DEGREE OF CONVERSION AND THERMAL ANALYSIS OF A DENTAL ADHESIVE CONTAINING NEW ANTIBACTERIAL MONOMERS

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Aim: adding antibacterial quaternary ammonium dimethacrylate monomers (QAMs) into a commercial 3-steps E&R adhesive resin (Adper ScotchBond Multipurpose, SBMP, 3M ESPE) can prevent the onset of secondary caries. In this study, four different antibacterial QAMs, designed and synthesized in our research laboratory (Italian patent n°102019000020949, publication date 20.10.21), were added to SBMP; degree of conversion (DC%) and thermal analysis of the obtained resin mixtures were investigated. The null hypothesis was that adhesive performance was not affected by the antibacterial QAMs.

Methods: the four patented experimental antibacterial QAMs were added at 1%(w/w) to SBMP. The degree of conversion (DC%) of SBMP adhesive containing QAMs was obtained by Attenuated Total Reflection Fourier Transform Infrared spec-

troscopy (ATR-FTIR) measurements of the resins (N = 10) before and after 40s of photopolymerization. Ten disks of each photopolymerized resin mixture (SBMP+1%QAMs) were thermally analyzed through Differential Scanning Calorimetry (DSC) and glass transition temperatures (T_g) were identified. Samples of pure SBMP were used as a control.

Results: DC% and glass transition temperature (T_g) of SBMP adhesive were not significantly affected by the presence of 1%(w/w) of the four different QAMs. In all samples tested, DC% values were around 74% and glass transition temperatures were similar to the SBMP baseline (71°C).

Conclusions: the null hypothesis was accepted, as glass transition temperature and degree of conversion of SBMP+1%QAMs were not significantly different from the control.

NEW PROSTHETIC RESIN PA12: MECHANICAL CHARACTERIZATION BY DMA OF AM VS MILLING TECHNIQUES

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Aim: in this paper the Young's Modulus (E) of a new resin Polyamide-12 (PA12) in Additive Manufacturing (AM) was evaluated and compared to a milled PA12 (TECAMID 12 natural) manufactured by Ensinger Italia S.r.l., Ensinger GmbH, Germany.

Methods: Young's Modulus (E) of AM PA12 was evaluated using Dynamic Mechanical Analysis (DMA).

To evaluate the Young's Modulus, six PA12 samples were analyzed by the "Three-Point Bending" test. The measurements were performed in frequency domain, ranging from 1 Hz to 100 Hz with an increase of 5 Hz, and a force amplitude of 1

N. Each sample was tested ten times to ensure statistical significance.

Results: the results showed a mean elastic modulus (E) of PA12 AM (2041.37 ± 236.13 MPa), with a statistical significance ($p < 0.05$), higher than milled one in PA12 (1700 MPa).

Conclusions: in conclusion, the manufacturing technique of PA12 influences the mechanical properties of the material. In particular, AM samples displayed suitable mechanical properties for dental prostheses. Future developments will be to study *in vitro* on oral human cell populations in order to verify biocompatibility and cytotoxicity.

VITRO BACTERIAL ADHESION TO IMPLANT SURFACES SUBJECTED TO FOUR DIFFERENT TREATMENTS

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Aim: bacterial adhesion to the surfaces of dental implants is an important factor for the development of peri-implant pathologies. The development of surfaces that reduce bacterial adhesion could reduce the development of peri-implant infections.

Methods: commercially pure titanium disks were subjected to the following surface treatments: machining (G1), machining and anodization (G2), sandblasting and etching (G3) and sandblasting, etching and anodization (G4). A reference strain of *S. aureus* (ATCC BAA-1717) was used for the *in vitro* adherence test. The materials were exposed under static conditions to a bacterial suspension of known concentration. Each material disk was placed on the bottom of a well, using sterile techniques, and exposed to a bacterial suspension having a cell concentration of 10^7 cells/mL in PBS buffer. One ml of cell suspension was added to each well. After incubation at 37°C for

4 h, the test materials were washed three times with 1 ml of a sterile PBS buffer solution in order to remove non-adhering cells. Each disk was placed in a glass tube containing 1 ml of PBS buffer. Bacteria adherent to the biomaterial surfaces were detached by sonication, bringing them into suspension. Serial dilutions of the bacterial cells suspensions were prepared and deposited onto BHI agar plates. The plates were incubated for 24 hours at 37°C and the number of colonies counted. The results are expressed as Colony Forming Units (CFU) per mL.

Results: bacterial adhesion was significantly different on the various surfaces. The anodizing treatment allows to reduce bacterial adhesion.

Conclusions: the surface treatment affects bacterial adhesion. Surfaces that reduce bacterial adhesion could reduce the onset of peri-implant pathologies.

METAL-FREE SURFACE ROUGHNESS AFTER ETCHING: SEM, AFM AND ALICONA 3D MICROSCOPE ANALYSIS

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Aim: acid etching increases micromechanical adhesion values in leucite-based ceramics. The aim of the study is to understand how the concentration of the acid used for etching can affect surface roughness while evaluating the formation of salt crystals and microcracks in the treated specimens.

Methods: six leucite-based ceramic samples were treated with three concentrations of hydrofluoric acid for 60 seconds followed by cold water rinsing for 20 seconds: HF9.5% (Ultradent, USA), HF5% (Ivoclar Vivadent, Liechtenstein), HF3% (DenMat, USA). The surface analysis was carried out using AFM, SEM (50x,100x,5.000x,10.000x) and 3D microscope Alicona Infinite Focus® (5x,10x,20x,50x,100x), based on Focus Variation (FV) technology.

Results: SEM's analysis showed a surface with larger fissures and microcracks in the most aggressively treated samples. The

AFM analysis confirmed the results showing the presence of a higher incidence of darker areas with maximum peak height (Sp) of 4.14µm in HF9.5%, and 2.53µm in HF3%. The Height Maps of the FV analysis showed greater superficial irregularities in the most aggressively treated specimens with an average roughness (Sa) of 0.85µm; the same value was equal to 0.81 µm for HF3% (FVM,10x).

Conclusions: etching increased roughness that is necessary for good adhesion. Greatest roughness was obtained after treatment with HF 9.5% although surface microcracks and salt crystals were observed in these specimens. Further studies could be carried out using the same acid concentration for shorter times to obtain a good roughness while avoiding the formation of crystals and the weakening of the material.

COMPARISON OF STRESS DISTRIBUTION BETWEEN ZIRCONIA AND BIO-HPP ABUTMENTS: A FEA STUDY

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Aim: bio-HPP (High Performance Polymer) is a biomaterial based on a semi-crystalline linear polycyclic thermoplastic polymer. Bio-HPP is used to manufacture dentures superstructure and implant abutment. This study aimed to evaluate, through Finite Element Analysis (FEA), how the stress distribution change in implant, abutment, and screw when two different abutments (zirconia VS Bio-HPP) were used.

Methods: two implant models with a resinous fixation cylinder simulated the peri-implant tissues. A compressive load was applied at 30 degrees from the implant axis, with magnitude of 100 N. A FEA software was used to evaluate the stress distribution in the implant-abutment-screw models. Von-Mises stress maps were calculated for the qualitative evaluation and the stress peaks values in each structure were obtained for quantitative comparison.

Results: regardless the abutment material, the highest stress peak values were observed in the abutment structure. There was a similar stress pattern between the models for the mechanical response. There is a higher magnitude for Bio-HPP, caused by the higher deformation generated at the loading moment. However, the inner portion with the implant connection was similar for both models.

Conclusions: it is suggested that CAD/CAM Bio HPP abutments present acceptable stress distribution pattern. The mechanical behavior of fixture and screw were not affected by the abutment material, however Bio-HPP showed a more concentrated area of stress distribution in the abutment when compared to Zirconia, due to its increased flexibility.

CONFOCAL LASER MICROSCOPE EVALUATION OF SURFACE ROUGHNESS: ZIRCONIA VS BIO-HPP

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Aim: the relationship between implant abutments and soft tissues creates a protective barrier to separate peri-implant bone from the oral environment. For many years, standard stock titanium abutments were the only option available. However, alternative materials such as ceramics, hybrid materials, composites, zirconia and PEEK can be used to achieve a better aesthetic result. The aim of this study was to evaluate the surface characteristics of two different types of CAD/CAM milled prototype made of a modified PEEK, (Bio-HPP Bredent, Senden, Germany) or Zirconia (Zirkonzahn, Steger, Ahrntal, Italy).

Methods: the surface roughness of 6 samples was analyzed with the confocal Laser microscope μ -surf (NanoFocus AG,

Oberhausen, Germany). For each sample, three different areas of $320 \mu\text{m} \times 320 \mu\text{m}$ were evaluated. The software (Version 6.0, NanoFocus AG, Oberhausen, Germany) was used to analyze the samples surface and to create the dataset.

Results: the data showed a mean Ra of $0,221 \mu\text{m} \pm 0.9 \mu\text{m}$ for Bio-HPP and $1.075 \mu\text{m} \pm 0.24 \mu\text{m}$ for Zirconia. Both surface profile had an adequate smoothness, regardless the measurement axis and roughness parameter.

Conclusions: CAD/CAM High Performance Polymer abutments could induce a better fibroblast cell behavior and produce an adequate than unpolished zirconia abutment. In conclusion, Bio-HPP can represent a valid alternative to titanium.

USE OF EARPHONES WITH ACTIVE NOISE CONTROL AS PROTECTIVE DEVICE AGAINST DENTAL WORK NOISE

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Aim: there are no protective measures against hearing damage caused by exposure to dental work noise that have been tested. This study has 4 aims: 1) estimate noise produced by dental instruments; 2) analyze the noise shielding capacity of earphones with Active Noise Control function; 3) estimate the average dental work noise; 4) evaluate the reduction of dental work noise and discomfort perceived by operator equipped with the earphones.

Methods: this study was organized in 4 phases: 1) 20 noise measurements of turbine, scaler and saliva aspirator in non-contact mode using a dummy head device, 2) following the same protocol of the previous phase, measurements were made using the earphones in 2 different active noise control functions, 3) 51 students of the Perugia Dental College, randomized into 3 groups like the 3 measurement modes of the pre-

vious phases, performed a dental work simulation, 4) 30 students performed a dental work simulation 2 times, at first not wearing the earphones, then having them on in "Noise Cancelling" mode.

Results: in non-contact mode, no instrument generates noise greater than 85 dB(A), while when used in contact with commercial ceramics values vary from 79.9 dB(A) to 100.6 dB(A). Earphones' noise shielding was about 40% and resulted effective in reducing noise discomfort.

Conclusions: although the earphones were not specifically designed for the study, the results were promising enough to promote further studies.

Future developments could involve the investigation of the main frequencies of dental noise and focus on them the acoustic shielding of the earphones.

MECHANICAL TYPING OF NARROW DIAMETER IMPLANT “EVEN”: FEM ANALYSIS AND CYCLIC FATIGUE

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Aim: the aim of this study is to evaluate the response of a new implant system “EVEN” with conometric connection, consisting of the implant (3.4 x 8mm), the connection screw and the abutment, to the stresses of cyclic fatigue. The implant system was subjected to preliminary finite element analysis (FEM) which made it possible to identify the areas of greatest stress to fatigue. Fatigue tests, performed according to ISO 14801/2016 (“worst possible case criteria”), allow to predict with a good approximation the clinical behavior of these prosthetic devices.

Methods: the fatigue test was performed in immersion in saline solution (n = 8) for 2X10⁶ cycles. At the end of each test, the survival or failure event of each sample was recorded. Scanning optical and electron microscopy was used to analyze fracture patterns and compare them with finite element analysis, finally, the force regimes used in the tests

were compared with the masticatory forces present in the literature.

Results: during the first test (210 N) (n = 4), all samples tested survived, setting a lower cyclic load limit (210 N) below which no failure occurred experimentally. A further test was performed, with a load increased by about 10%, (240 N) (n = 4). At the end of the test, three successes and one failure were recorded. At this point the cyclic fatigue resistance test is considered finished by defining a limit value between 210N and 240N.

Conclusions: the coincidence of the theoretical data (FEM) with the experimental ones, together with the comparison with the masticatory forces reported in the literature, allows to predict that the system can withstand with a high degree of safety the wide spectrum of static and dynamic stresses that it may encounter during clinical function, in particular when used in the anterior sectors of the dental arch.

REFLECTIVITY AND MECHANICAL BEHAVIOUR OF ORTHODONTIC COMPOSITE

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Aim: relationships between reflectivity and chemical composition of the dispersed phase in orthodontic composites: Transbond XT (3M Unitek), Light-Cure Orthodontic Paste (Leone) and Bisco Ortho Bracket Paste LC (Bisco), were *in vitro* investigated to evaluate if reflectivity results can be useful to interpret mechanical behaviors and not only optical qualities of these resins.

Methods: 8 discs of each composite were realized for a total of 24 samples. By Lambda 35 UV/Vis spectrophotometer, light transmission through the resins was measured, evaluating the spectral range from 190-1100 nm, at samples preparation (T₀),

after 24 hours (T₁) and after 10 days (T₂) of immersion in 5 ml Coke® or human saliva.

Results: the reflectivity spectra revealed that Bisco has the highest reflectivity, Leone shows an absorption pattern in the UV region very similar to Bisco and TXT shows the lowest reflectivity compared to the other two resins.

Conclusions: Bisco and Leone, due to the low and similar filler content, explain the similarities in mechanical performance which are lower than those of TXT whose higher filler content, in particular quartz as observed by the UV-Vis analysis, makes it the composite clinically more used for orthodontic bonding.

EFFECT OF PRIMERS CONTAINING FLUORINATED GRAPHENE ON THE ADHESION OF FIBER-GLASS POSTS

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Aim: to evaluate the effect of 2%wt fluoride graphene (FG) on the push-out bond strength (PBS) of 10-MDP-based primers used for fiber post luting.

Methods: twenty single-rooted human teeth were endodontically treated and prepared to receive fiber posts [Hi-Rem R103 (HR) and Hi-Rem Plus (HR+); Overfibers s.r.l., Italy]. The dentin and fiber post surfaces were pre-treated with primers experimentally saturated with 2%wt FG. Then, the luting procedures were performed with a post-and-core resin cement (OverCO-RE). Groups were formed according to the primer (with/out FG) and fiber post type (n = 5): 1. CTRL + HR, 2. FG 2% + HR; 3. CTRL + HR +; 4. FG 2% + HR +. After 24h, specimens were cut into slices and submitted to the PBS test. Data were stati-

stically analyzed ($p < 0.05$). Additionally, the fractographic analysis with stereomicroscope was conducted on debonded beams.

Results: no statistically significant differences were found among groups, independent of the presence of 2%wt FG or fiber post type ($p > 0.05$). The most predominant failure mode was at the dentin-cement and post-cement interfaces in all the tested groups. Higher percentage of post-cement deboning were observed in the FG groups, independent of the fiber post.

Conclusions: independent of the fiber post type, the results suggest a possible use of 2%wt fluoride graphene for enhancing dentin adhesion. Long-term studies are warranted to confirm the results.

THE USE OF ADHESIVE SYSTEMS FOR A MULTIDISCIPLINARY CONSERVATIVE THERAPY OF EICR

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Aim: the diagnosis and the treatment of External Invasive Cervical Resorption (EICR) could be a challenging clinical situation even for the most experienced dentists. It is a quite rare lesion, a poorly understood phenomenon, and its insidious and aggressive nature can lead to tooth loss. Even in dental implant era, try to save a compromised tooth it is imperative for any clinicians. The aim of this report is to show a complex clinical case managed thanks to the use of modern restorative materials.

Methods: this report presents a case of an upper central incisor's EICR (Heithersay class II) in which the treatment was carried out using a multidisciplinary approach and the defect was

restored with resin composite; besides, the endodontic treatment was completed thanks to the use of a resinous cement and a fiber-reinforced posts.

Results: the use of modern materials not only made it possible to avoid tooth extraction, but also to achieve satisfactory aesthetic results. The follow-up at 6 years demonstrated the success of the therapy and the absence of clinical symptoms.

Conclusions: after an analysis of the scientific literature, the authors through this case underline the importance of EICR early detection and how the composite resins could offer an effective and aesthetic restoration of the defect and also good health of gingival tissue.

CUSTOMIZED PCL/ β -TCP 3D-PRINTED SCAFFOLDS FOR BONE AND PERIODONTAL REGENERATION

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Aim: personalized blocks presenting morphological and mechanical features, able to fit bone or periodontal defects, are leading to a strong amelioration of patient care. The main objectives of this project are to: define the optimal mixture of polycaprolactone/ β -tricalcium phosphate (PCL/ β -TCP), obtain customized 3D-printed scaffolds and evaluate their biological effectiveness.

Methods: PCL/ β -TCP powders have been used to create filaments for 3D-printers at relative percentages of 60/40 and 30/70 and customized scaffolds have been obtained through 3D-printing.

100%PCL has been used as control. Scaffolds wettability and biological effectiveness (i.e. cytotoxicity, cell proliferation and gene expression) have been tested in the regards of MC3T3-E1 osteoblasts.

Results: filaments showed adequate mechanical/physical characteristics for 3D-printing, with a higher concentration of β -TCP if compared to literature data (up to 60%). Surface wettability appeared similar on all the samples and biological assays did not show the release from composite mixtures of any toxic agent in the culturing medium. Nevertheless, cell proliferation on both PCL/ β -TCP samples increased during the time in a significative manner. The expression of genes related to bone differentiation (i.e. BSP, OCN, OPG) was higher on PCL/ β -TCP samples if compared to PCL.

Conclusions: we validated the possibility to drastically enhance up to 70% the amount of β -TCP loaded in a PCL filament obtaining a composite material presenting optimal characteristics for 3D-printing. PCL/ β -TCP scaffolds showed a good effect on both, biocompatibility and cell differentiation.