FROM KINEMATICS TO DIAGNOSIS: DIGITAL MANDIBULAR MOTION ANALYSIS IN TMD PATIENTS

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Aim: to assess whether mandibular motion tracings obtained from a novel jaw tracking system can identify specific patterns in patients with temporomandibular disorders (TMDs), moving from descriptive kinematics to diagnostic interpretation.

Materials and methods: patients were evaluated according to DC/TMD. Mandibular motion was recorded using an optical tracking system with eight markers: four as cranial references and four on the mandibular arch. Movements included opening-closing, gothic arch, and mastication cycles, integrated with intraoral and facial scans in a CAD environment. Evaluation criteria were linearity, amplitude, and simmetry of excursions.

Results: ten patients were classified according to DC/TMD. The system enabled reconstruction of mandibular trajectories, showing altered kinematic patterns compared with physiological references. Myogenous patients exhibited reduced functional amplitude without major trajectory alterations, but with asymmetric laterality and restricted, predominantly axial mastication. Arthrogenous patients showed deviations during opening, instability in gothic arch tracings, and unilateral mastication. However, variability limits clear diagnostic thresholds.

Conclusions: mandibular tracking provides objective functional recording and may support dysfunction identification, but it is not a standalone diagnostic tool. Clinical validation is limited by methodological heterogeneity and lack of standardization; therefore, kinematic data should be interpreted alongside clinical examination and validated criteria.

CELLULAR RESPONSE OF HUMAN OSTEOBLASTS TO NEW DEPROTEINIZED BOVINE BONE: A COMPARATIVE AND *IN VITRO* STUDY

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Aim: considering the wide application of bovine bone in the treatment of bone defects, a new composition of the deproteinized ones was evaluated on human osteoblast-like MG-63 cells, to test the biocompatibility and the effects on proliferation and osteoregulator expression.

Methods: MG63-cells were cultured and treated with granule-conditioned medium (GCM) for 6 and 24 h. After selection of time and concentration by MTT assay, GCM was used alone or in combination with GFs (TGFβ 5ng/mL+PDGF 5ng/mL) and compared with untreated sample. Confocal and SEM image for morphological analysis were collected, alongside protein and gene expression of key targets. Data were analyzed by one-way ANOVA with post-hoc tests.

Results: among the tested concentrations 10 µg/mL of GCM did not affect cell viability after 24 hours. Confocal and SEM images highlighted the ability of GCM to increase cell density and size, which was more evident when combined with GFs. Expression of bFGF, RUNX1, RUNX2, VEGF, BMP2, IL6, IL1β, and MMP9 highlighted the ability of GCM, in association with GFs, to induce an increase in VEGF, bFGF ($p < 0.005$), BMP2 ($p < 0.001$), and MMP9, with reduction in RUNX1($p < 0.001$), all of which are involved in osteoblast proliferation and maturation.

Conclusions: this study identified that GCM exhibits biocompatibility and significantly enhances the MG63 proliferation and osteogenic gene expression. Interestingly, the synergic activity with TGFβ and PDGF enhances osteoinductive and remodeling-related signals, supporting potential utility in guided bone regeneration pending *in vivo* validation.

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EXPERIMENTAL ANALYSIS OF THE MECHANICAL PROPERTIES OF RESINS FOR PROSTHETIC DEVICES: 3D PRINTING *VS* CONVENTIONAL TECHNIQUES

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Aim: this study aimed to investigate the reasons behind the higher fracture incidence observed in 3D-printed complete denture bases by evaluating differences in flexural strength, elastic modulus, and fracture toughness compared to conventional resin.

Methods: a total of 42 standardized specimens and one maxillary complete denture were produced according to ISO 20795-1:2013. Two 3D-printing resins (V-Print Dentbase, V-Print C&B Temp) and one cold-cured resin (ProBase Cold) were tested. Flexural strength and elastic modulus were evaluated using three-point bending tests, while fracture toughness was assessed with a dedicated test. The FIMEC (Flat-top cylinder Indenter for Mechanical Characterization) method, previously used primarily for metallic materials, was also applied to compare elastic modulus with yield point and HIT hardness.

Results: ProBase Cold showed significantly higher flexural strength, elastic modulus, and fracture toughness compared to both 3D-printed materials, indicating significant differences in mechanical performance. However, HIT hardness was comparable between ProBase Cold and V-Print Dentbase.

Conclusions: the mechanical properties of the tested 3D-printed materials are inferior to those of conventionally processed resin, which may explain their higher susceptibility to fracture in clinical applications.

PH VARIATION IN ARTIFICIAL SALIVA AFTER THE ADDITION OF AN OZONE MOUTHWASH AND A CHLORHEXIDINE MOUTHWASH: AN *IN VITRO* STUDY

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Aim: the oral cavity is a complex ecosystem in which about 700 bacterial species contribute to oral homeostasis. Disruption of this balance may favor pathogenic microorganisms involved in caries, plaque-induced gingivitis, and periodontitis. Since environmental changes influence oral biofilm composition, preventive strategies may target not only pathogens but also local conditions. This *in vitro* study evaluated pH changes induced by an ozonized mouthwash compared with a 0.20% chlorhexidine mouthwash.

Methods: the oral environment was simulated using 100 mL of artificial saliva (*Fusayama/Meyer Artificial Saliva*). pH was measured with a digital pH meter at baseline (T0) and after 15 s (T1), 30 s (T2), 40 s (T3), and 60 s (T4) following addition of 10 mL ozonized mouthwash (Oz) (Cliadent *Ozonoil, Budetta Farma s.r.l., Salerno*). The same protocol was performed with 10 mL 0.9% NaCl and 10 mL chlorhexidine (0.2% CHX) (Cliadent *Ozonoil, Budetta Farma s.r.l., Salerno*). ΔpH was calculated for all groups over time.

Results: oz showed a progressive increase from T0 to T3 (ΔpH +0.54), with minimal variation from T3 to T4 (+0.01). CHX showed a similar trend (ΔpH +0.43 from T0 to T3; +0.04 from T3 to T4). NaCl showed stable pH values. Forty seconds of exposure to Oz and CHX were sufficient to induce a positive ΔpH in artificial saliva, while longer exposure did not produce meaningful additional changes.

Conclusions: both ozonized and chlorhexidine-based mouthwashes increased salivary pH under these *in vitro* conditions. This alkalinizing effect may support an oral environment more favorable to health-associated bacterial species.

CIRCULAR ORTHODONTICS: CLINICAL FEASIBILITY OF ADVANCED BIOPOLYMERS AND DEGRADATION PROTOCOLS FOR ZERO-IMPACT ORTHODONTIC THERAPY

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Aim: this study analyzes an experimental protocol for the sustainable management of non-biodegradable thermoplastic polymers (PETG and TPU) used in orthodontics. The aim is to define an "in-office" pre-treatment procedure for deep decontamination and volumetric reduction of plastic waste, facilitating subsequent mechanical recycling.

Methods: the protocol consists of a systematic mechanical fragmentation phase to increase the surface-to-volume ratio of the polymer, followed by a reactive washing process. Samples were immersed in a 20% aqueous citric acid solution, followed by the addition of sodium bicarbonate to trigger a controlled effervescent reaction with the release of carbon dioxide.

Results: chemical analyses reported in the literature confirm the inertness of ester and urethane bonds in PETG and TPU toward weak acid hydrolysis; no dissolution or degradation of the polymer matrix is observed. However, the effervescent reaction acts as an effective mechanical cleansing agent, promoting the removal of bacterial biofilms and organic contaminants from the surface of the fragmented material. The process significantly reduces the storable volume of waste without generating toxic emissions or complex liquid by-products.

Conclusions: the proposed protocol does not represent a chemical disposal method based on polymer dissolution, but rather a hygienic pre-treatment and compaction strategy. This procedure converts the used medical device into an inert, decontaminated material suitable for disposal within plastic recycling streams, thereby minimizing environmental impact and supporting circular economy approaches in clinical practice.

EVALUATION OF BISPHENOL A RELEASE FROM PEDIATRIC DENTAL RESTORATIVE MATERIALS UNDER DIFFERENT PH AND TEMPERATURE CONDITIONS: AN *IN VITRO* STUDY

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Aim: Bisphenol A (BPA) is a chemical compound of concern in pediatric dentistry due to its potential health risks in children. This study evaluated BPA release from seven pediatric restorative materials: *Cention Forte Filling Material, Equia Forte HT Fil, Stela Self Cure, Riva Light Cure, Riva Self Cure, Fuji IX GP Fast*, and *Cention Primer*.

Methods: disk specimens (10 mm diameter, 2 mm thickness; n = 3 per material) were prepared according to manufacturers' instructions and immersed in buffer solutions at pH 4.8, 6.8, and 8.8. Samples were stored at 37 °C and 44 °C for 1, 7, and 28 days. BPA release was analyzed using high-performance liquid chromatography coupled with mass spectrometry (HPLC-MS).

Results: BPA release was highest under acidic conditions at 44 °C, particularly after 1 day of exposure. Cention Primer showed the highest BPA release, reaching 1.31 ± 0.17 µg/L after 1 day at 44 °C in acidic conditions. Stela Self Cure followed with 0.51 ± 0.10 µg/L under the same conditions. Under neutral and basic conditions, BPA release was not detected for most materials, except for Cention Primer.

Conclusions: within the limitations of this *in vitro* study, BPA release from pediatric restorative materials appears to be influenced by pH, temperature, and exposure time. The findings reflect short- to medium-term behavior (up to 28 days) and cannot be extrapolated to long-term clinical safety. These results highlight the importance of minimizing BPA exposure in children by prioritizing BPA-free restorative materials when possible.

PULSED ELECTROMAGNETIC FIELDS DIFFERENTIALLY REGULATE PROLIFERATION, MIGRATION AND MATRIX DEPOSITION IN GINGIVAL FIBROBLASTS

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Aims: to evaluate the effects of pulsed electromagnetic fields (PEMFs) on human gingival fibroblasts and to determine whether different exposure regimens selectively modulate biological processes relevant to oral soft tissue regeneration.

Methods: primary human gingival fibroblasts were exposed to PEMFs 75 Hz, 1.5 mT, under two conditions: acute stimulation (single 8-hour exposure) and repeated stimulation (8 hours/day). Untreated cells served as controls. Cellular responses associated with oral wound healing were assessed, including viability/proliferation, collagen deposition, clonogenic potential, and wound healing capacity.

Results: both acute and repeated PEMF exposure significantly increased cell viability and collagen deposition compared to controls, indicating enhanced extracellular matrix production. Repeated stimulation induced a more pronounced proliferative response, suggesting a cumulative effect on fibroblast expansion. In contrast, acute exposure preferentially enhanced cell migration and wound closure in the scratch assay. Clonogenic capacity was also increased following PEMF stimulation, supporting an effect on progenitor-like cell behavior.

Conclusions: seventy-five Hz PEMF stimulation promotes key cellular functions involved in oral soft tissue regeneration in a regimen-dependent manner. Acute exposure appears to favor migratory processes associated with early wound healing, whereas repeated stimulation enhances proliferative responses linked to tissue maturation. These findings suggest that PEMF protocols may be strategically tailored to different phases of oral healing, supporting their potential application in regenerative dentistry.

OMD-ZNO–MODIFIED COMPOSITE RESINS: EFFECTS ON KERATINOCYTE VIABILITY AND BIOCOMPATIBILITY

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Aim: this study aimed to investigate the biological and microbiological effects of OMD-ZnO incorporation into composite resins on human keratinocytes.

Methods: composite resins containing 0% (control group), 0.5%, and 1.5% w/w OMD-ZnO were prepared by manual mixing under controlled light conditions and molded into standardized cylindrical specimens, followed by light-curing. OMD-ZnO consisted of a hydroxyapatite-based OMD (85% hydroxyapatite, 15% $CaCO_3$) combined with zinc oxide obtained from zinc acetate and subsequently silanized to improve compatibility with the resin matrix. Samples were immersed in culture medium to obtain conditioned media at 24, 48, and 72 hours. Human keratinocytes were cultured under standard conditions and exposed to conditioned media. Cell viability was assessed by MTT assay at 24, 48, 72 hours, and 7 days. Surface morphology was analyzed by FE-SEM.

Results: conditioned media from both control and OMD-ZnO composites showed a time-dependent reduction in cell viability up to 72 hours. At day 7, a significant increase in viability was observed for the 1.5% OMD-ZnO group compared with other samples. SEM analysis confirmed homogeneous dispersion of the filler.

Conclusions: OMD-ZnO incorporation induces an initial reduction in cell viability, followed by a significant improvement over time, particularly at higher concentrations. These findings suggest a concentration-dependent biological response and support further investigation of higher OMD-ZnO contents.

MECHANICAL AND BIOLOGICAL PERFORMANCE OF CARBON- AND KEVLAR-REINFORCED ETHYLENE VINYL ACETATE (EVA) COMPOSITES FOR DENTAL APPLICATIONS

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Aim: to evaluate the influence of carbon and Kevlar fiber reinforcement on both the mechanical properties and biological response of ethylene-vinyl acetate (EVA)-based composites, assessing their potential for dental applications.

Methods: mechanical properties were assessed through three-point bending tests, highlighting the role of fiber reinforcement in increasing strength and stiffness, as well as in modulating stress distribution.

The biological response was subsequently investigated *in vitro* using MTT assay on human oral keratinocytes. Conditioned media were obtained from sterile discs of materials immersed in culture medium (3 h/day for 6 days). The media were collected from EVA, reinforced composites and uncoated fibers, and cell viability was evaluated at 24 and 72 h of treatment.

Results: mechanical testing demonstrated that fiber reinforcement improves material strength and stiffness, reducing stress concentration and enhancing structural stability. At 24h, pure EVA showed a marked reduction in cell viability (67-75%), whereas reinforced composites exhibited higher values (77-83%); uncoated carbon showed the highest viability (85-90%). At 72 h, a general recovery in cell viability was observed: EVA reached 72-92%, while Kevlar-reinforced composites exceeded control levels (108%), suggesting a potential proliferative effect. The remaining groups ranged between 54-74%.

Conclusions: fiber reinforcement not only enhances the mechanical performance of EVA but also appears to positively influence its biological behavior. However, further *in vitro* studies, including those on oral fibroblasts, are required.

IN VITRO EVALUATION OF THE BIOLOGICAL RESPONSE OF A 3D-PRINTABLE DENTAL RESIN MODIFIED WITH SIO_2, TI-BASED AND ZIRCONIA NANOPARTICLES

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Aim: to evaluate the effect of nanoparticle incorporation (SiO_2, Ti-based, zirconia) on the biological response of a 3D-printable dental resin (Keyguard Sportguard Resin).

Methods: four materials were tested: a control resin and resins modified with SiO_2, Ti-based, and zirconia nanoparticles. Samples were 3D-printed, polymerized, and UV-sterilized. Human oral keratinocytes were used. Direct-contact MTT assay was not feasible due to interaction with the tetrazolium salt; therefore, the effect of direct contact was assessed by automated cell counting at 24 and 72 h. Indirect testing, used conditioned media (3 h/day for 6 days), was evaluated by MTT assay at 24, 48, 72 h, and 7 days.

Results: in direct contact, zirconia-modified resin showed the highest viability at 24 h, while Ti-based samples showed an initial reduction. At 72 h, SiO_2 samples exhibited a marked decrease, whereas Ti-based samples showed recovery, suggesting time-dependent cellular adaptation.

Under indirect conditions, all materials showed a progressive decrease in viability. At 24 h, values ranged from 56-86%. At 48-72 hours, viability dropped to 25-58%, indicating cumulative effects of released compounds. At 7 days, control, SiO_2, and Ti-based samples showed comparable values (28-63%), while zirconia remained lower (12-39%).

Conclusions: SiO_2 and Ti-based nanoparticles show biocompatibility comparable to the control, supporting their use in modified dental resins. Zirconia showed a more variable response, suggesting the need for further optimization. Indirect testing proved essential for unstable materials. Further *in vitro* studies are required.

EVALUATION OF THE EFFECT OF THERMO-MECHANICAL AGING ON THE STRENGTH OF CAD-CAM LITHIUM DISILICATE SPECIMENS: A PILOT STUDY

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Aim: to evaluate the influence of thermo-mechanical aging on the flexural strength of a CAD-CAM lithium disilicate restorative material.

Methods: CAD-CAM lithium disilicate sticks (12 × 2 × 2 mm) (Initial LiSi Block, GC Dental) were prepared by means of a low-speed microtome and measured using a digital caliper. The specimens were casually divided into four groups (N = 8): control (T0) and thermo-mechanically aged groups corresponding to 1 (T1), 3 (T3), and 5 (T5) years. Aging was performed using a chewing simulator (240,000 cycles/year, 50 N load) combined with thermocycling (5-55°C) in distilled water. The specimens were then subjected to three-point bending tests until fracture using a universal testing machine, in accordance with UNI-EN-ISO 178 standards. Values (MPa) were analyzed using non-parametric ANOVA and the Dwass-Steel-Critchlow-Fligner test.

Results: mean flexural strength was 196 +/- 53 MPa (T0), 193 +/- 70 MPa (T1), 191 +/- 69 MPa (T3), and 149 +/- 43 MPa (T5). A decreasing trend with aging was observed, more evident at T5, though differences were not statistically significant ($p > 0.05$).

Conclusions: the analyzed material exhibited a trend toward reduced mechanical properties following thermo-mechanical aging; however, this decrease was not statistically significant. It is plausible that different materials may exhibit different behaviors depending on their specific characteristics. Further studies are therefore required to investigate potential decrease in mechanical strength.

INFLUENCE OF PLATELET-RICH PLASMA ACTIVATED WITH HYALURONIC ACID ON ENDOTHELIAL ANGIOGENIC RESPONSE: INSIGHTS FROM *IN VITRO* GROWTH FACTORS PROFILING

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Aim: this *in vitro* study evaluates the effects of platelet-rich plasma (PRP) activated with cross-linked hyaluronic acid (CHA) on endothelial cell proliferation and the release of angiogenic mediators.

Methods: peripheral blood from 10 healthy volunteers was collected to prepare pure platelet-rich plasma (PRP) using the Idria® G kit. Human endothelial cells were cultured under four different conditions: endothelial basal medium (ECBM), ECBM + 5% PRP, ECBM + 5% PRP-activated with a low concentration of CHA (0.9%), and ECBM + 5% PRP-activated with a high concentration of CHA (1.8%).

Cell proliferation was assessed for 13 days. After 13 days, cell-conditioned media were analyzed using the RayBio® C-Series Human Angiogenesis Antibody Array Kit to evaluate secreted angiogenic mediators.

Results: a significant increase in endothelial cell proliferation was observed in the three PRP groups, regardless of CHA activation, compared with the ECBM group.

Cell-conditioned media analysis revealed higher release of angiogenin, GRO (α/β/γ), and ANGPT-1 in the PRP-CHA groups. In contrast, ANGPT-2 release decreased, suggesting a shift toward a vascular maturation profile.

Conclusions: PRP, either alone or activated with CHA, enhances cell proliferation and promotes the release of vascular maturation factors rather than early angiogenic sprouting factors.

Further *in vitro* studies are required to investigate the regenerative effects of hyaluronic acid at higher concentrations, closer to those used in clinical settings for periodontal regenerative procedures and post-surgical healing.

EFFECTS OF PLATELET-RICH PLASMA ACTIVATED WITH CROSS-LINKED HYALURONIC ACID ON HUMAN FIBROBLASTS: AN *IN VITRO* STUDY

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Aim: the aim of this study was to evaluate the effects of platelet-rich plasma (PRP) activated with cross-linked hyaluronic acid gel (CHA) (Regedent, Zurich, CH), at two different concentrations, on human fibroblasts, focusing on proliferation and mediators' release.

Methods: human fibroblasts were cultured under four conditions: DMEM plus 5% FBS; 5% PRP activated; PRP activated with a low concentration of CHA (0.9%); and PRP activated with a high concentration of CHA (1.8%). Cell proliferation and mediators' release were analysed and grouped according to their known roles during the healing phases.

Results: PRP, either alone or activated with CHA, significantly increased fibroblast proliferation compared to the untreated control group. PRP promoted the release of mediators such as IL-6, GM-CSF, ENA-78, RANTES, and angiogenin, while reducing the release of MCP-1, OSM, and TARC. PRP activated with CHA enhanced immunoregulatory mediators, such as IL-7, and enhanced angiogenic signaling mediators in addition to IL-13 and SDF-1.

Conclusions: *in vitro* PRP stimulates fibroblasts' proliferation compared with untreated controls, confirming its well-known mitogenic role. Moreover, it promotes the fibroblasts' secretion of several mediators known to be involved in tissue healing. PRP activated with CHA does not significantly enhance proliferation compared with PRP alone, but it does enhance the secretion of IL7, IL-13, SDF-1, and other angiogenesis mediators.

EVALUATION OF THE BIODENTINE-RESIN-BASED MATERIAL INTERFACE: COMPARISON OF SHEAR BOND STRENGTH BETWEEN TWO OPERATIVE PROTOCOLS

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Aim: this study aimed to evaluate the shear bond strength (SBS) at the interface between Biodentine™ XP and a resin-based material by comparing two different restorative strategies.

Methods: a total of 24 samples were prepared using acrylic resin blocks containing a standardized central cylindrical cavity filled with Biodentine™ XP. The specimens were randomly divided into two groups (n = 12). In Group 1, Biodentine™ XP was immediately covered with Vertise™ Flow and a bulk-fill resin-based material. In Group 2, Biodentine™ XP was allowed to set for 15 minutes, after which a universal adhesive system was applied, followed by a bulk-fill resin-based material. After 30 minutes, SBS was measured using an Instron universal testing machine, and failure modes were evaluated under an optical microscope. Data were analyzed using the Mann-Whitney test, with the level of significance set at $p < 0.05$.

Results: SBS values were higher in Group 2 than in Group 1. Specifically, Group 2 showed a mean SBS of 14.57 ± 7.05 MPa, whereas Group 1 showed lower values (9.31 ± 3.73 MPa). The comparison between groups using the Mann-Whitney test revealed a statistically significant difference ($p = 0.0256$). Fracture analysis showed that adhesive failures predominated in Group 1 (70%), whereas cohesive failures were more frequent in Group 2 (80%).

Conclusions: complete setting of Biodentine™ XP resulted in higher SBS values and a greater percentage of cohesive failures, suggesting more reliable and predictable bonding performance. However, when a rapid restorative protocol is required, the use of unset material still provided acceptable bond strength values and failure patterns.

MATERIALS-OCCLUSAI: ARTIFICIAL INTELLIGENCE FOR BIOMATERIAL SELECTION BASED ON MANDIBULAR FUNCTIONAL ANALYSIS

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Aim: the objective of this study is to present Materials-OcclusAI, an AI-based platform, designed to support the clinician in selecting the most appropriate restorative biomaterial.

Methods: a systematic database was structured on the chemical-biomechanical properties of the main restorative biomaterials (composites, ceramics, zirconia, glass ionomers). The patient's clinical data were acquired through a dedicated web interface, including cavity characteristics, biological conditions, and relevant habitual factors; mandibular kinematics were recorded with optical tracking of facial landmarks (chin and lip commissures) during masticatory cycles and guided movements. An AI model analyzed the functional parameters (amplitude, speed, and laterality) to estimate occlusal load and detect parafunctions. The algorithm finally integrated the material properties with the patient's dynamic profile to identify the optimal restorative solution.

Results: in 50 clinical cases, the model showed an accuracy of 80% in the selection of the biomaterial. The agreement with the gold standard was substantial (Cohen's Kappa = 0.73). ROC analysis showed an average AUC of 0.87, indicative of a high discriminative ability between the different categories of biomaterials.

Conclusions: the Materials-OcclusAI approach transforms the choice of biomaterial from a static evaluation to a dynamic prediction based on individual mechanical stress. This decision support system allows aligning the structural properties of the restoration with the patient's functional stresses, optimizing biomechanical stability over time.

IMPACT OF THE DENTAL SECTOR ON THE ENVIRONMENTAL POLLUTION

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Aim: this review aims to evaluate the environmental impact of the dental sector, focusing on the contribution of dental materials, clinical practices, and waste management to environmental pollution, and to highlight sustainable alternatives.

Methods: a systematic review of the literature was conducted using PubMed and Google Scholar databases, covering publications from January 2000 to March 2025. Keywords included "dental waste," "environmental pollution," "green dentistry," "microplastics," and "mercury."

Results: the findings indicate that dentistry significantly contributes to environmental pollution through plastic waste, heavy metals (especially mercury and silver), microplastics from resin-based materials, and high energy and water consumption. Amalgam use remains a major source of mercury contamination, while disposable plastics and biomedical waste pose long-term ecological risks. Additional impacts derive from radiographic chemicals, patient/staff travel, and inadequate recycling practices.

Conclusions: the dental sector has a substantial environmental footprint. Adoption of green dentistry principles — such as reducing waste, limiting hazardous materials, improving resource efficiency, and promoting prevention — can significantly mitigate its impact. Sustainable clinical choices and increased awareness are essential for transitioning toward environmentally responsible dental care.

CLINICAL APPLICATIONS OF RESORBABLE CALCIUM PHOSPHATE PHASES IN ALVEOLAR BONE REGENERATION: A SCOPING REVIEW ON BRUSHITE, MONETITE AND TRICALCIUM PHOSPHATE BIOMATERIALS

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Aim: resorbable calcium phosphate biomaterials, including tricalcium phosphate (TCP), brushite, and monetite, have been proposed as alternatives to stable materials such as hydroxyapatite for alveolar bone regeneration. This scoping review aimed to map the available clinical evidence on their use in alveolar regenerative procedures.

Methods: a scoping review was conducted following PRISMA-ScR guidelines. Searches were performed in PubMed, MEDLINE, Scopus, and Web of Science. Clinical studies on brushite-, monetite-, or TCP-based biomaterials were included, comprising randomized controlled trials, prospective studies, and case series. Data were descriptively extracted on study design, indications, surgical protocols, biomaterials, healing time, outcomes, and complications.

Results: seven clinical studies were included, covering ridge preservation, ridge augmentation, and periodontal or intraosseous defects relevant to implant placement. Marked heterogeneity was found in study design, defect characteristics, biomaterials, and outcomes. Overall, brushite- and monetite-based materials showed progressive resorption and new bone formation, supported by clinical, radiographic, and histological findings.

Conclusions: evidence remains limited and heterogeneous. Although these biomaterials show good biocompatibility and resorbability, current data are insufficient to establish comparative clinical effectiveness. Further well-designed randomized trials with standardized protocols are needed.

METAVERSE AND ARTIFICIAL INTELLIGENCE: A FUTURISTIC SYNERGY BETWEEN DIGITAL IMMERSIVENESS AND ADVANCED COMPUTERIZATION

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Aim: the aim of the research is to critically evaluate the available evidence on the use of the metaverse and immersive technologies in dentistry, defining the state of the art and future prospects in the fields of oral health education and promotion and dental training.

Methods: a literature review was conducted on Scopus, PubMed, and Google Scholar (2020-2025), selecting the most relevant articles evaluating VR/AR-based programs, metaverse platforms, and AI tools, considering their areas of use and main outcomes.

Results: the available literature is limited but consistent in showing benefits for dental training and oral hygiene prevention. In dental surveys, interest in the metaverse is high, but knowledge of dental applications remains low (~20.6%). Immersive environments improve the learning of complex anatomy (5-point Likert scale score of ~4.7/5) and reduce anxiety in pediatric settings. The major clinical applications that have emerged remain as possibilities, perceptions, or scenarios, which speak of improved planning and diagnosis, virtual procedure walkthroughs, remote consultations, support for surgical precision, and 3D visualization of endodontic anatomy.

Conclusions: the metaverse-AI combination shows high immersive-educational potential; however, quantitative evidence specifically on the metaverse is still limited, heterogeneous, and short-term. Interest in its use is high, but translation into practice requires robust clinical studies, definition of technical and ethical standards, sustainable economic models, and digital literacy programs for students and professionals. The main challenges include high costs, data security issues, and a lack of digital skills.

ANALYSIS AND COMPARISON OF BITEMARKS USING DIGITAL SCANS AND 3D RESIN CASTS IN AN EXPERIMENTAL CASE STUDY

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Aim: the use of bitemark analysis in personal identification remains controversial, even if dental patterns are considered unique. This study aims to compare two different techniques for bitemark analysis: a digital method based on the superimposition of digital scans of dental patterns and lesions, and a visual method based on the physical superimposition of resin casts produced by 3D printing.

Methods: a sample of 12 volunteers with a mean age of 26 years was collected as biters. Each subject was asked to bite on a support made from semi-rigid water bottles covered with dental wax. Dental arches were recorded using an intraoral scanner, while bitemarks were impressed with PVS and then recorded using the same scanner. Resin casts of both the dental arches and the bitemarks were 3D printed. Scan superimposition analysis was conducted using CloudCompare, while resin casts were physically superimposed by a blind operator. Both superimposition techniques relied on the selection of 10 corresponding landmarks between dental arches and impressions.

Results: digital superimposition showed an average concordance of 92.5% for the upper arch landmarks and 85% for the lower ones, with an overall average concordance of 88.8%. In contrast, visual analysis of resin casts showed an average concordance of 77.5% for the upper arch and 76.7% for the lower arch, with an overall average of 77.1%. In the analysis performed using CloudCompare, the maxillary arch demonstrated the best superimposition, with 4 points consistently overlapping and it outperformed the visual analysis in all four quadrants, particularly in the upper right arch compared to the lower left one.

Conclusions: these results support the integration of digital techniques in forensic applications, although further studies are necessary to validate the digital technique on a larger and/or different sample.

STUDY OF SOME BONE BIOMARKERS (P1NP, PTHRP, TRACP, CTX) ON SALIVARY MATRIX DURING ORTHODONTIC TREATMENT WITH CLEAR ALIGNERS: A PRELIMINARY STUDY

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Aim: the aim of the study was to evaluate changes in the concentration of N-terminal type I collagen extension pro-peptide (PINP), tartrate-resistant acid phosphatase (TRAcP), parathyroid hormone-related protein (PTHrP) and C-terminal telopeptide of type I collagen (CTX) in saliva during orthodontic treatment with clear aligners to evaluate changes in bone turnover markers (BTM) concentration.

Methods: saliva samples from 21 apparently healthy young subjects (9 females and 12 males) were collected using Salivette® with cotton swabs. The concentrations of PTHrP, TRAcP, P1NP, CTx were analyzed at time 0 (T1), at 25 (T2), 45 (T3), 60 (T4) and 90 days (T5). Mann Whitney U test was used for comparison of means between different groups.

Results: the trough concentrations of P1NP, PTHrP, TRAcP, CTX were 0.80 ug/L, 0.21 ng/mL, 0.90 U/L, 0.10 ug/L. Mann-Whitney U test did not showed statistically significant variations between T1 *vs* T2 for the analytes considered, while statistically significant variations were observed between T1 *vs* T3, T4 and T5 for P1NP, TRAcP, CTX. PTHrP showed significant variations only in T1 *vs* T3. The data obtained demonstrate that PTHrP plays a regulatory role, while P1PNP, CTX, TRAcP exhibit significant variations over the time periods studied.

Conclusions: these data indicate that the aligners induce slow but continuous tooth movement, as both resorption and apposition markers, with significant changes after 45 days, show a constant and continuous increase in the following months. This type of treatment appears to be more respectful of bone physiology.

ARTIFICIAL INTELLIGENCE FOR STANDARDIZING POLISHING PROCEDURES IN RESTORATIVE DENTISTRY: A RANDOM FOREST MODEL TO PREDICT SURFACE ROUGHNESS AND REDUCE OPERATOR-DEPENDENT VARIABILITY

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Aim: differences in pressure, working time, rotation speed, and abrasive sequence affect the final surface roughness of restorative materials. This study analyzes interactions among operative parameters and aims to identify optimized, reproducible polishing protocols supported by artificial intelligence models.

Methods: a dataset was created from literature data. Variables included restorative material, tooth group, abrasive grit size, and operator-dependent parameters (rotation speed and working time). A Random Forest machine learning model was trained to predict surface roughness based on these variables and their interactions.

Results: the model identifies optimized protocols using decreasing-grit sequences, standardized times, and constant speeds, achieving significant roughness reduction. Lower values are predicted for microhybrid composites and hybrid CAD-CAM materials, while lithium disilicate shows slightly higher values. Optimal protocols reach the 0.2 μm threshold, indicating reduced bacterial adhesion. In clinical testing, 4/7 dentists reported reduced working time and improved surface uniformity; 3 noted partial discrepancies with their habits but acknowledged the system's value as a decision-support tool in daily practice.

Conclusions: standardizing grit size, rotation speed, and working time improves predictability of polishing procedures. Model performance (R^2 >0.8) confirms reliability, reducing operator-dependent variability and enabling more uniform surfaces below the critical threshold for bacterial adhesion, supporting more consistent clinical outcomes.

MAKING DENTAL COLOR MEASUREMENT ACCESSIBLE: AN AI-ASSISTED SMARTPHONE PROTOCOL WITH CROSS-POLARIZED LIGHTING

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Aim: to propose a smartphone digital workflow for dental colorimetry using cross-polarized lighting and our custom AI-integrated web app. Our protocol provides an objective, standardized, and cost-effective method, bridging the gap between subjective visual matching and expensive clinical spectrophotometers, with a lower learning curve than DSLR setups.

Methods: our custom web app calibrates smartphone sensors via a 24-color target, generating a Color Correction Matrix (CCM) to neutralize native post-processing. The app processes 16-bit TIFFs acquired via our standardized setup: cross-polarized dual RGBWW LEDs (CRI >95) at 45°, a fixed working distance maintained via a physical guide, and a neutral gray card. The software autonomously performs CIELAB conversion and computes ΔE00 against a hardware-calibrated digital VITA database.

Results: preliminary *in vitro* validation confirmed the app accurately matches shades to the hardware-calibrated VITA standard. Notably, despite unshielded ambient light pollution (daylight and room lights), the test recorded a mean ΔE00 of 1.58 (SD ± 0.65) and a 78% success rate (ΔE00 ≤1.8), demonstrating high immunity to environmental optical noise.

Conclusions: this protocol assists clinicians by reducing economic barriers and learning curves in objective dental colorimetry. Leveraging our web app, clinicians obtain reproducible data in aesthetic rehabilitations, with a potential role in legal protection. Ongoing studies will evaluate cross-device consistency and *in vivo* accuracy.

HYALURONIC ACID: OPTIMIZED USE OF THE BIOMATERIAL FOR GINGIVAL BIOMIMICRY THROUGH ARTIFICIAL INTELLIGENCE

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Aim: Hyaluronic acid (HA) is a glycosaminoglycan and the material of choice for the aesthetic regeneration of soft tissues. Due to its viscoelastic and hydrophilic properties, it promotes fibroblast activity, epithelial trophic effects and gingival collagen organization. However, stability depends on operator-dependent variables and intrinsic polymer properties (elastic and viscous moduli G' and G", cross-linking, molecular weight, concentration). This study defines quantitative protocols integrating these parameters with computational predictive models, evaluating material behavior in oral tissues.

Methods: a digital platform was developed; it integrates intraoral imaging and radiographs to quantify volumetric defects by analyzing geometric-anatomical models and gingival biotype. The software simulates hydrogel behavior by incorporating its rheological properties, predicting diffusion kinetics and tissue integration.

Results: the algorithm suggests injection sites and simulates the final volume, providing a success index and a personalized reinjection protocol. The model correlates rheological properties with volumetric predictability, optimizing performance on application technique. Currently in an expansion phase, the system serves as a decision support tool.

Conclusions: this approach enhances a biochemically validated biomaterial, ensuring controllable and reproducible use. Synergy between physicochemical parameters and computational modeling permits precise HA management, improving aesthetic predictability through a minimally invasive and repeatable procedure.

NEXT-GENERATION ALLERGOVIGILANCE: AN ADVANCED AI-DRIVEN ALLERGEN SURVEILLANCE PLATFORM FOR MAPPING ALLERGENICITY AND CROSS-REACTIVITY IN DENTAL BIOMATERIALS

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Aim: adverse reactions to dental biomaterials remain a clinical challenge that is often underestimated, also due to the fragmentation of information in literature. The aim of this study is to create a systematic allergovigilance protocol, capable of mapping the allergenicity and potential cross-reactivity of dental materials and providing a decision-support tool for clinicians in selecting safe therapeutic alternatives.

Methods: a structured literature review was conducted to build a comprehensive allergen-biomaterial dataset. For each compound, key information was collected and standardized: CAS code, chemical family, cross-reactivity and associated materials. These data were organized within a relational architecture designed to be queried using AI, enabling the visualization of complex allergenic clusters that would otherwise be difficult to identify.

Results: data analysis led to the development of a platform that allows the exploration of relationships between allergens, biomaterials, and clinical reactions, providing an overview of dental materials' safety. Critical allergenic clusters were identified, including different classes of acrylates, metal allergens, and phenolic compounds such as eugenol.

Conclusions: the developed platform is configured as an easily consultable clinical tool capable of guiding the dentist in the conscious use of biomaterials, in order to reduce the risk of iatrogenic complications and increase the level of clinical safety. Its future implementation in daily clinical practice represents a fundamental step toward personalized and evidence-based medicine.

ARTIFICIAL INTELLIGENCE FOR PATIENT-SPECIFIC RESTORATIVE MATERIAL SELECTION: A PREDICTIVE DECISION SUPPORT SYSTEM IN RESTORATIVE DENTISTRY

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Aim: to develop an AI-assisted decision support system for restorative dental material selection based on material properties and clinical indications, in order to identify the most suitable option for each clinical scenario.
Methods: a digital platform was developed for the structured collection of clinically relevant variables involved in restorative material selection. The algorithm was trained on an integrated dataset including technical data sheets of major direct and indirect restorative materials and literature data on their clinical use. The system combines material properties, tooth characteristics, and biomechanical, functional and aesthetic requirements to generate a personalized recommendation associated with a predictive success score, and a comparison with alternative materials. Validation was performed by twelve independent operators on five standardized clinical cases. For each case, operators rated the appropriateness of the recommendation on a three-level ordinal scale. Inter-operator agreement was assessed using Fleiss' kappa coefficient.
Results: statistical analysis using Fleiss' kappa coefficient showed a statistically significant result (? = 0.31; p <0.01), indicating good decision-making consistency.
Conclusions: the prevalence of "appropriate" and "partially appropriate" ratings supports the clinical validity of the system's recommendations. The platform proposes an innovative decision-making model in which material properties and scientific evidence converge to support more consistent, personalized and predictable restorative material selection.

PREDICTING COLOR STABILITY IN ALIGNERS: A COMPUTATIONAL MODEL INTEGRATING PATIENT HABITS AND MATERIAL PROPERTIES

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Aim: to evaluate differences in color stability among the main polymers used in orthodontic aligners and to develop a computational model to predict color variation (ΔE) as a function of patient habits, integrating mechanical and surface parameters.
Methods: the model was built using available scientific data on aligner materials and their pigmentation. It consists of a two-level algorithm: in the first level, patient habits are standardized in terms of exposure times and associated with pigmentation values reported in the literature; this information is then aggregated to estimate total discoloration. In the second level, this result is converted into a risk score, simplifying its interpretation. The system also provides an illustrative visualization of staining to make the result more intuitive.
Results: TPU materials show higher ΔE values (≈3–6) compared to PETG (≈1–3). Coffee and red wine are the main drivers, with ΔE >5 under high-exposure conditions. Smoking acts as an incremental surface factor. The scores identify high-risk profiles exceeding the threshold of aesthetic acceptability (ΔE >3.3). The model was tested on 22 aligner wearers: 18 considered it consistent with their real experience.
Conclusions: the model highlights how susceptibility to staining depends on the interaction between polymer type, patient habits, and material characteristics. The integration of data allows for a personalized estimation of ΔE and an intuitive synthesis of risk, supporting material selection and the aesthetic management of orthodontic treatment.

FROM SIMULATION TO CLINICAL DOCUMENTATION: FINITE ELEMENT ANALYSIS FOR MECHANICAL EVALUATION AND MEDICO-LEGAL SUPPORT OF CAD-CAM PROSTHETIC RESTORATIONS

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Aim: to explore the potential of Finite Element Analysis as a support for the biomechanical evaluation of materials used in CAD-CAM rehabilitations and for the structuring of technical-scientific clinical documentation, also applicable in the medico-legal field. The aim is to propose a replicable model to integrate simulation data into prosthetic documentation, improving traceability, clinical communication and documentary support.

Methods: a 3D digital model of a CAD-CAM crown on a mandibular molar was developed and subsequently analyzed through FEA simulation. The geometry was discretized into a finite element mesh, and mechanical parameters were assigned based on literature data and material technical datasheets. Occlusal load was simulated by applying distributed forces on the three functional cusps of the occlusal surface.

Results: the analysis evaluated the distribution of Von Mises stresses and strain gradients, generating colorimetric maps highlighting areas of higher stress concentration in relation to occlusal loading. The model enabled visualization of the biomechanical behavior of materials used in rehabilitations and the synthesis of results into a structured technical report.

Conclusions: it is possible to obtain a patient-specific biomechanical report through FEA, useful for guiding material selection and improving the traceability of decisions. This approach assumes a relevant role in the medico-legal field, providing clinicians with an additional level of protection through objective, reproducible, and shareable documentation, including with the patient.

A DYNAMIC EDUCATIONAL TOOL FOR LEARNING AND UPDATING DENTAL MATERIALS KNOWLEDGE

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Objective: the increasing variety and technical complexity of dental materials make it challenging for both students and clinicians to quickly access reliable and well-structured information. The study aims to develop an AI-based encyclopedic system using Retrieval-Augmented Generation (RAG) architecture to generate relevant and accurate responses to user queries.

Methods: a structured database of dental materials was developed using selected scientific and educational sources, which were subsequently organized and classified. The encyclopedic system is built on a RAG architecture implemented in Python within a Google Colab environment. It processes user queries through semantic search techniques, retrieving the most relevant information and using it to generate concise and contextually appropriate responses. Forty dentistry students evaluated the system's usefulness using a five-point Likert scale (completely useless, not very useful, neutral, useful, very useful), in order to assess both informational effectiveness and clarity of presentation.

Results: descriptive statistical analysis showed that 37 out of 40 students (92.5%) gave a positive evaluation (useful or very useful). The system proved effective in handling diverse queries in terms of both content and grammatical structure, maintaining consistency and relevance in its responses.

Conclusions: these results highlight the potential of semantic retrieval-based systems in managing dental knowledge, suggesting possible applications to support learning and improve access to information in academic settings.