3785 Two Body Wear Study of Gypsum.

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Recently, gypsum products have been modified with resins to improve handling properties, one of them being wear resistance. The purpose of this study was to compare the wear resistance of resin-containing dental stones {Garreco:Apex(A), Talladium: Tuff Rock (TR), Whip Mix: Resin Rock (RR), American Diversified: Die Rock (DR) and type IV dental stones {Garreco: Excaliber (E), Modern Materials: Die Keen (DK)} using a two-body wear model. For each stone, fifteen vacuum-mixed specimens (10 mm height x 3.5 mm diameter), made with the manufacturers' water:powder ratio were made by pouring into polyvinyl siloxane cylindrical molds. Twenty-four hours after removal from the molds, specimens were cyclically abraded over a water-flushed diamond impregnated disc. Height loss per cycle was recorded with a microcomputer/LVDT construct. A linear least squares regression fit of the data yielded the wear rate for each specimen Mean wear rate values in µm/revolution with standard deviations are given below.

E (ab)	M (ab)	A (a)	TR (b)	DK (b)	RR (b)	DR (ab)
8.9±1.1	9.6±1.3	8.6±1.1	10±1.2	10.2±1.2	10.0±2.1	9.9±0.8

Analysis of variance revealed significant differences between the stones ($p \leq 0.05$). The REGQW test found A's wear rate was statistically less ($p \leq 0.05$) than TR, DK, and RR. E, M, and DR were not statistically different from the other stones. Addition of resin to dental stone can increase wear resistance in some but not all cases. Partial support: NIH DE07155-13, OSU Medical Research Initiative.

3786 The Rheological Characterization of Dental Waxes

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The rheology of waxes is fundamental to the majority of their applications in dentistry, but it has never been systematically investigated. The usual method for characterizing "flow" is unacceptably arbitrary and uninterpretable in physico-chemical terms. The determination of the viscosity of waxes poses serious technical problems, in part due to very large thermal expansion. It was the purpose of this work to identify an objective method for wax rheometry and to apply it with a view to establishing the range of behaviour of dental products. The modified Stokes' falling ball method (Darvell & Wong, 1989) was used to study 11 waxes over the temperature range 25 - 45°C under a wide range of strain rates. The method was found to be usable over at least 7 orders of magnitude in viscosity, 7 in terminal velocity and 3 in load, which ranges are believed to be unprecedented for a rheological method. Waxes were shown to be pseudoplastic, lacking any identifiable yield point; the departure from Newtonian behaviour was marked. The pseudoplasticity varied with temperature, and related to the reduced temperature, referred to the liquidus. Because of the stress-dependency of the pseudoplasticity a master curve cannot be constructed. In addition, discontinuities are present in the viscosity contours with respect to load and strain-rate. These may be due to stress melting of individual phases. A Standardized Viscosity Number, defined at 30°C and under 10 N load on a 3 mm ball, as the logarithm of the apparent viscosity, is proposed as a single, convenient characterizing number for dental products. For the waxes tested, this ranged from 5.8 to 15.3. Similarly, a Shear Thinning Exponent, the reciprocal of the pseudoplasticity parameter, provides a similarly convenient measure of the stress sensitivity of waxes. The waxes tested had values ranging from 2.3 to 7.7. Objective comparison of waxes can now be made.

3787 Effect of Post-processing Treatment on Resilience of Tissue Conditioners.

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Pressure/heat and glaze coating were reputed to improve longevity of tissue conditioners by sealing plasticizer from leaching. The purpose of this study was to test the hypothesis that additional treatment can help maintain resilience of tissue conditioner. We selected Lynal, Coe-Comfort, Coe-Soft and Tempo for the study. Treatment modalities were as-prepared per manufacturer's instruction, subsequent pressure/heat treatment, mono-poly coating (one part PMMA in 10 parts autopolymerizing MMA), and Jet Seal (a commercial coating). Six specimens each (25x25x6 mm) were prepared per material/treatment combination. After baseline test, all specimens were tested again after storage in distilled water for 2, 7, 14, 28, 42, 63 and 84 days using a dynamic testing system, Instron Model 8511, to characterize resilience of the material. The medium was replaced after each test. The specimen was first compressed to 0.65 mm at a rate of 0.05 mm/s, the actuator head then switched to cyclic motion using 0.65 mm as the midpoint with an amplitude of ±0.5 mm at ½ cycle/s for 15 cycles. Elastic modulus was calculated. Cyclic peak loads, L_n, at each cycle, n, were used to estimate the recovery rate, τ, by: $L_n=L_0*\exp(-n/\tau)$, where L_0 is the estimated peak load at n=0. The results show that the range of elastic moduli in MPa were 0.16~1.66 for Lynal, 0.36~1.03 for Coe-Comfort, 0.34~1.51 for Coe-Soft, and 0.31~1.14 for Tempo. The rates of recovery in $cycle^{-1}$ were 34~176 for Lynal, 43~99 for Coe-Comfort, 51-145 for Coe-Soft, and 37~127 for Tempo. ANOVA indicates that the effects of treatment and storage time on either measurement are statistically significant ($p<0.01$). Tukey's grouping shows that significant changes often occur during the first two weeks. The effect of treatment on individual materials was different. Tukey's grouping shows for most materials coatings caused higher elastic moduli, an indication of higher resilience, and lower τ than as-prepared, while the effect pressure/heat was inconclusive. Post-processing treatment may not help maintain resilience of all tissue conditioners tested; the increase in elastic modulus may have resulted from the presence of coating itself.
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3788 Digital 3D-measurement method for accuracy testing of dental impressions

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The accuracy of dental impressions is determined by measurements of definite lines. Therefore, common methods are limited to a two-dimensional analysis. The aim of this study was to develop a new method for the analysis of three-dimensional errors of dental impressions. The method bases on a CAD-surface model of a prepared upper canine. A metal-die was milled as a high-precision physical copy using a NC-milling-machine. Ten monophase impressions were taken (Impregum, ESPE, Germany). The casts poured with a type IV die stone (Fujirock EP (GC-Belgium)) were digitized optically. The digitized data set was compared with the CAD-surface model using Surfacer® (Imageware Inc., USA). Differences between the CAD-surface-model and the digitized data set were displayed by color-coded graphs. The differences show complex three-dimensional patterns of deviation up to 65 µm, which were located especially at edges. The presented in-vitro 3D-analysis of the accuracy of dental impressions shows typical deviations confirming clinical experience. It performs a suitable in-vitro-testing of impressions. This study was supported in part by the TMWFK (Thuringian Ministry of Science, Research and Culture), Grant B 403-97005.
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3789 Cytotoxicity of Dental Amalgams of Different Composition.

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In the controversial discussions about possible side effects dental amalgam is often sweeping assessed. On the other hand there are marked differences in the composition of the alloys and the properties of the materials available on the market. The objective of our study was to compare the cytotoxicity of dental amalgams in relation to the composition of the alloys. 11 different types of amalgams were investigated: different kinds of silver- and copper-rich amalgams as well as types containing antimony, indium, palladium or zinc. The cytotoxicity was assessed with human epithelial cells (Hep2) and mouse fibroblasts (L-929) using the agar overlay method as well as growth inhibition tests with extracts from the materials under investigation. In each case ten cylindrical specimens (r = 2 mm, h = 4 mm) of the different amalgams were placed on the surface of the agar and incubated for 24 hours. The lytic zones around the specimens were measured macro- and microscopically. For the growth inhibition tests in each case 5 cylindrical specimens were incubated in 10 ml supplemented DMEM (Gibco) with 10% FCS and Penicillin-Streptomycin for 7 days at 37°C. The extracts were filtrated and dilutions of the filtrates (up to 1:512) were applied into 96 well tissue culture plates (Nunc) with the cells. The medium was removed after 72 hours. The cell proliferation was assessed by measuring the cellular protein using the Lowry-test. Viability was measured with the MTT-test. Each of the growth inhibition tests was repeated at least 3 times. Specimens made of PMMA-autopolymer, glass, and a precious gold-alloy were used as reference. By ranking analysis the amalgams were classified with regard to their cytotoxicity. Amalgams containing low-percentage silver, high-percentage-copper, or Palladium turned out to have the lowest cytotoxicity; the strongest reactions were caused by amalgams with high-percentage silver, Zinc, and one of the Indium-containing amalgams. Our study shows that there are considerable differences in the cytotoxicity of gamma-2-free amalgam types depending on their composition.

3790 Low-dose, long-term effects of dental metal ions on monocyte proliferation.

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Metal ions are acutely toxic to cells (over 24-196 h) *in vitro* at sufficiently high concentrations. However, ion release from dental materials often occurs at lower concentrations over longer periods. Our hypothesis was that if the exposure time of cells was extended to 4 weeks, the conc. altering cellular proliferation would be lower. **Methods:** Human THP-1 monocytes were cultured with ions (Ni, Cu, Ag, and Hg) at 1-10% of established 24-h 50% toxicity concentrations previously published (Ni: 400 µmol/L; Cu: 550; Ag,: 90; Hg: 20, Dent Mater, 11:239-245, 1995). Controls contained only the anions. At weekly intervals for 4 weeks, cell cultures (n = 3) were counted (hemocytometer) and replated with 200,000 cells, fresh medium, and metal ions. Cellular proliferation was expressed as a percentage of control cultures and compared to controls with ANOVA (Tukey). **Results:** Ni ions decreased cell number 10-60% at 10-40 µmol/L in week (wk) 1, which declined an additional 20% from wk 3 to 4 ($p < 0.05$). Cu initially suppressed cell number by 25-50% (20-60 µmol/L), but cell number gradually increased over the next 3 wk ($p < 0.05$). At 12 µmol/L, Ag caused a 20% drop in cell number in wk 1 ($p < 0.05$), which then reversed to a 20% increase over controls in wk 3, then an 80% decrease in wk 4. Hg progressively decreased cell numbers ($p < 0.05$) over the 4 wk period at conc. of 0.2-1.5 µmol/L. The 1.5 µmol/L conc. decreased 100% by wk 4; the 0.2 µmol/L conc. dropped 30% by wk 3 ($p < 0.05$). **Conclusions:** Long-term (4 wk) exposure of Ni, Cu, Ag, and Hg ions to monocytes alters proliferation at concentrations far lower than previously reported, shorter-term (24-h) 50% toxicity values. These lower concentrations and times may be more relevant to *in vivo* release of metals from many dental materials. (Supported by Metalor and the MCG Biocompatibility Program).

3791 Cytotoxicity of Dental Implant Alloys treated with Lipopolysaccharide.

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Previous research has shown that lipopolysaccharide (LPS) is tenaciously adsorbed onto dental implant alloys. (*J Prosthet Dent* 77:76-82, 1997) The role of adhered LPS on dental implants is not known, but could cause or alter inflammatory responses in tissues adjacent to implants since LPS is a potent inflammatory mediator. We hypothesized that implant metals exposed to LPS may alter the metabolic or secretory activity of monocytes. METHODS: Specimens of CrCoNi, Ti (cpTi) and Ti alloy (TiAlV) were polished, cleaned and disinfected. The material control was Teflon (Tf). Alloys were exposed first to saline for 24 h, then to +/- 50 µg/mL of E.Coli LPS in saline for an additional 24 h (n=3, each condition). After this conditioning, alloys were transferred into cultures of human THP-1 monocytes for 24h. Cellular controls were monocytes +/- LPS added directly. Monocytic metabolic activity was assessed by succinic dehydrogenase (SDH) activity (MTT method). Monocytic secretory activity was assessed by TNF-α secretion into culture medium (ELISA kit). LPS treated vs. untreated conditions were compared with ANOVA and Tukey intervals ($\alpha = 0.05$). RESULTS: Alloys untreated with LPS demonstrated no significant SDH depression compared to Tf controls. However, LPS-treated CoCrNi and TiAlV suppressed SDH activity by 18-35% compared to Tf ($p<0.05$). No alloy caused TNF-α secretion without LPS exposure. LPS-treated alloys all caused significant ($p<0.05$) TNF-α secretion approaching positive cellular controls (360-650 pg/mL). If LPS-treated alloys were then eluted into saline for 7 days before exposure to monocytes, TNF-α secretion was only seen for Ti and TiAlV alloys at reduced but significant levels (80-135 pg/mL, $p<0.05$). CONCLUSIONS: In this *in vitro* system, LPS-treated alloys altered metabolic and secretory activity of monocytes. Thus, exposure of implant alloys to LPS may be an important consideration in the biologic response of adjacent tissues. (Supported by the MCG Biocompatibility Program)

3792 Metallic Ion Concentrations in Subcellular Fibroblast Fractions

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The objective of this study was to evaluate the ion concentrations present in cultured human gingival fibroblast fractions exposed to metallic salt solutions. Cells were exposed to salt solutions containing Be+2 (8ppm), Cr+3 (100ppm), Cr+6 (0.5ppm), Mo+6 (100ppm), or Ni+2 (30 ppm) for 72 hours. The cells were then homogenized and separated into fractions: cytoplasm, low density microsomes, mitochondria, nucleus, plasma membrane, and total membrane. Atomic absorption spectroscopy was performed and the metallic ion content in the fractions was compared to previously reported cytotoxic and metabolic analyses. Duncan's multiple comparison test at 0.05 significance level was used to determine if any of the cellular fractions contained higher ion concentrations per milligram protein. Plasma membrane fractions contained the highest Cr +6 concentration supporting the theory that Cr+6 reduces to Cr+3 in complete cell culture media, which is known to bind to the plasma membrane. Nuclear and mitochondrial fractions also contained elevated concentrations of Cr+6 supporting cytotoxic and metabolic data from previous studies in our laboratory. Plasma membrane fractions exhibited an elevated Mo+6 concentration, which provides an explanation for the plasma membrane depressions observed in earlier TEM studies. Cytoplasmic fractions contained elevated Ni+2 concentrations supporting the hypothesis that Ni is involved in lipid droplet formation, and suggesting alterations in metabolic function occur upstream of the mitochondria. In conclusion, atomic absorption spectroscopy of cellular fractions from fibroblasts exposed to metallic ions can add to an in-depth understanding of the cytotoxic and metabolic responses elicited by ions released from dental alloys.