1473 Effects of Cross-linking Agents on Properties of HEMA-based Denture Base Resin.

T. Arima[1,2]*, T. Hamada[1], and J.F.McCabe[2] ([1] Hiroshima Univ. Japan and [2] Univ. of Newcastle upon Tyne. UK)

The use of 2-hydroxyethyl methacrylate (HEMA) based polymer as a biocompatible material has been well established. The purpose of this study was to investigate the effects of cross-linking agents on transverse bending properties, water sorption and solubility, and dynamic mechanical behavior of HEMA-based denture base resin and to obtain a better understanding about the relationship between these properties and molecular structure. Poly(ethyl methacrylate) powder and HEMA based liquids which contain six different cross-linking agents, ethylene glycol dimethacrylate, EGDMA; diethylene glycol dimethacrylate, triethylene glycol dimethacrylate, 1,4-butanediol dimethacrylate, 1,6-hexanediol dimethacrylate, trimethylolpropane trimethacrylate, in concentrations ranging from 0 to 80% were used for all specimens. Specimens for transverse bend strength test and water sorption and solubility test were prepared according to ISO specification 1567. Specimens for dynamic mechanical analysis were subjected to a sinusoidal tensile strain at a frequency of 3Hz. The temperature was increased from -80°C to 300°C at a rate of 5°C/min. ANOVA and Tukey's HSD multiple comparison were used to find significant differences. The table shows the effect of adding EGDMA. The results indicate a significant effect on all properties by addition of EGDMA($p<0.01$). In addition, difference among cross-linking agents have become evident. These results can be explained by chain length, flexibility, and chemical nature of cross-linking agents, and by cross-link density.

Percentage EGDMA	E	Water Sorption	Solubility	E' (temp.)	tan δ
0	0.17 (0.06)	20.67 (0.76)	2.64 (0.28)	-	-
20	0.86 (0.03)	8.95 (0.12)	2.43 (0.26)	6.44 (223.7)	0.060
40	1.39 (0.06)	5.65 (0.11)	2.38 (0.21)	32.50 (220.0)	0.059
60	1.60 (0.06)	3.46 (0.14)	2.36 (0.54)	69.50 (206.5)	0.052
80	1.16 (0.07)	1.84 (0.07)	3.38 (0.62)	139.00 (189.7)	0.043

E = Modulus of Elasticity GPa, Water Sorption and Solubility μg/mm³, E' = Storage Modulus MPa in Rubbery Plateau Region, temp °C, tan δ = loss tangent in Rubbery Plateau Region.)

1474 Water Uptake of Soft Lining Materials from Osmotic Solutions.

S PARKER*[1], P.RIGGS[1], S. KALACHANDRA[2,3], M BRADEN[1] and D.F.TAYLOR[3] ([1]London Hosp. Med. Coll., London, UK; [2]VA Tech, Blacksburg, VA; [3]UNC Dent. School, Chapel Hill, NC)

The water uptake characteristics of soft lining materials are of obvious importance as they are expected to function in an aqueous environment. Novus (Hygienic Corp., U.S.A.) has been reported to have a high uptake from distilled water (abstract #1383 IADR, 1994). Despite this high uptake, Novus appears to function satisfactorily in the mouth. It has been proposed (Parker and Braden, Biomaterials 10:91-95, 1989) that high water uptake of elastomeric materials is caused by water soluble impurities which, on immersion, form solution droplets. The driving force is the osmotic gradient between the droplet and the external solution. Uptake should therefore be less from ionic solutions. In this study water uptake of Novus and four experimental materials based on butadiene styrene copolymer with methacrylate monomers has been assessed from distilled water and two saline solutions (0.45M and 0.9M). 0.9M saline has a similar osmotic pressure to saliva. After 196 days specimens were desorbed to constant weight and then underwent a second sorption. Results for the first sorption from water show Novus to have the highest uptake (18%), the uptake of the experimental materials was 4-6%. All materials showed a higher uptake for the second sorption. Uptake from the saline solutions was reduced to 1-2% for all materials, those in 0.9M having the lowest. Second sorption results from solution were similar to the first. The results support the theory that water uptake of elastomeric materials is lower from ionic solutions. The reduced uptake of Novus from solution could explain its satisfactory clinical performance. Supported by NIH-NIDR, DE09425.

1475 Creep and Dynamic Mechanical Behavior of two Denture Base Resins.

T.K. VAIDYANATHAN* and J. VAIDYANATHAN (NJ Dental School, UMDNJ, NJ 07103).

Lucitone 199 (LC) and Acron MC (AC) are two PMMA based denture base resin systems based on heat and microwave methods of curing, respectively. The clinical longevity of the dentures fabricated from these systems may be influenced by the post-cure creep and dynamic mechanical properties (viscoelastic properties) of the resins. The objectives of this study were to evaluate the flexural creep and viscoelastic behavior of LC and AC. A TA Instruments DMA model 983 was used to study the creep and viscoelastic behavior. Specimens (25mm x 10mm x 2.5mm) were fabricated in a mold and cured as per the manufacturer's instructions. For the creep study, creep-recovery cycles in the temperature range of 0 to 45°C were carried out in the DMA using a constant displacement of 0.40 mm. The viscoelastic behavior was evaluated at 1 Hz using an oscillation amplitude of 0.60 mm in the temperature range of -50 to 180°C. Sample size, N = 4 for creep and 7 for viscoelastic analysis. Results: The mean and (SD) values of creep compliance ($\mu m^2/N$), storage modulus (GPa) and loss modulus (MPa) values, respectively, at 37 °C for the two systems studied are LC: 619.9 (46.8), 2.41 (0.21), 220 (35.1); AC: 568.68(49.7), 2.32 (0.27), 192.2 (23.3). Statistical analysis by student t-test revealed no significant differences between mean creep, storage and loss modulus values at 37°C ($p>0.05$). The α glass transition temperatures for both resins occured at approximately the same temperature range of 90 to 115°C, but the β transition occured at 19 to 32°C for LC and 30-44°C for AC. The results indicate generally similar creep and viscoelastic behavior for the two systems, although there are some differences.

1476 Water Sorption of Microwave, Self and Heat Cure Resins,

A. SAMANT*, J. VAIDYANATHAN and G. GILL. UMDNJ-NJDS, Newark NJ, USA

Although microwave curing offers important advantages in the fabrications of denture bases over conventional curing, inadequate information is available on the properties of microwave cured denture base resin. According to the manufacturer, the microwave cured resins contain less porosity. Since watersorption may be influenced by the porosity, the objective of this study was to evaluate the water sorption of ACRON-MC (microwave cure resin) and compare against Lucitone (heat cure resin) and Repair Acrylic (self cure resin). 50mm diameter X 0.5 mm thick discs were prepared and tested according to ADA specification #12 as per the manufacturer's directions for the respective resins. Sample size, N =15 was used.

Results: Mean and SD values of water sorption in mg/cm^2 are as follows ACRON MC: 0.0071(0.00018); LUCITONE=0.00082 (0.0004), SC ACRYLIC= 0.00049(0.0004). One way ANOVA showed no significant differences in the mean value of the different systems tested ($p>0.05$). It is concluded that water-sorption of microwave cured denture base resin is comparable to those of heat cure and self cure systems.

1477 Use and Design of Magnets in Denture Retention.

A.P. Dias* and B.W. Darvell (Prince Philip Dental Hospital, The University of Hong Kong, Hong Kong).

Although rare-earth alloy magnets have been used to retain prostheses and to move teeth for over fifteen years, the literature on these systems can be characterised in general as lacking reference to physical principles: retention expressed as force per unit mass or force per unit volume of magnet assembly; the force-distance relationship said to be according to the inverse square law; the inverse square law at small separations and an inverse root relationship at large separations and a direct square relationship initially followed by a direct cube relationship; the stated need for a keeper of specified thickness and the need for special high permeability alloys. Data are now presented to demonstrate that the expected force distance relationship approaches an inverse fourth power law. The keeper may be a plane of infinitesimal thickness; its relative permeability ceases to be important for $\mu/\mu_0 > \sim 200$ in that the retentive force could then be improved by no more than 1% at any given distance. From the above it follows that : in retention systems, even a very small increase in the distance between magnet and keeper for whatever reason would significantly reduce retention; the design of orthodontic tooth movement systems should take the force-distance relationship into consideration if a rapid rise or fall of force with tooth movement is to be avoided; the keeper thickness has no bearing on the retention; the development of special high permeability keeper alloys would be a waste of time and effort. The development and design of dental magnets and procedures should take account of these factors if the clinical outcome is to be satisfactory.

1478 Simultaneous Determination of Leachable Substances from Denture Base Polymers.

T. HONGO* and A. SATO (Tokyo Medical and Dental University, Tokyo, JAPAN).

Residual monomer levels in denture base polymers have become very important from the point of view of the quality of dental resins and biocompatibility. While there have been several reports regarding levels of residual monomer in acrylic resins, little is known of reports concerning quantitative analysis of all substances leached out from acrylic resins except monomer. The purpose of this study is to develop a new determination method for leachable substances in acrylic resins using HPLC. Conventional heat-cured acrylic resins(ACRON; GC Corp., Japan) were used as a specimen and were immersed in ethanol. The identification and determination of leachable substances was performed by using HPLC. For good separations of leachable substances, acetonitrile-10 mM phosphate buffer pH 2.5 (1:1) and a polymer-coated C_{18} column (Shiseido Comp. LTD., Japan) was required. Main leached substances were methyl methacrylate (MMA), benzoyl peroxide (BPO) and the decomposition of BPO, benzoic acid (BA) and ethyl benzoate (EB). These substances were eluted in the order of BA, MMA, EB, BPO. Amounts of BA, MMA, EB and BPO leached out from the acrylic resin for 2 weeks were 0.033, 0.98, 0.003 and 0.14 mg/g resin, respectively. These results suggest that this HPLC-analysis is highly useful to identify and determine simultaneously some substances leached out from acrylic resins by solvent-immersion. This work was supported in part a Grand-in-Aid for Scientific Research from the Ministry of Health and Welfare of Japan and in part a Grand-in-Aid for Scientific Research (No. 05454529) from the Ministry of Education, Science and Culture of Japan.

1479 Computer-Aided-Instruction by Virtual Reality System in Clinical Dentistry.

S. TSUTSUMI* and T. NAMBU (Research Center for Biomedical Engineering, Kyoto University, Kyoto, JAPAN).

In Clinical Dentistry, the heuristic knowledge of dynamic treatment procedures such as diagnosis, treatment planning and communication with patients may rather be hardly obtained only from references or manikin training. Employing new computer technology, i.e. Virtual Reality (VR) system, our approach is to develop a "therapeutic simulator" whereby the skill of remedy of expertized dentists can be inherited intuitively by dental trainees. As an interface device specially customized for dental application a multi-linked 3D digitizer was developed to obtain positional and kinematic data of the hand movement of dentists during treatment, as well as the preliminary application imitating the cavity and tooth preparation with this VR system. At the free end of the digitizer a dental handpiece was mounted to measure the 3D position of tools by which the user can communicate with the 3D world in the computer. The digitizer has 7 links with 7 (6 + 1 excess) degrees of freedom as much as those of the human arm, and at every link a photo rotary encoder was set to compute the movement of the handpiece with accuracy better than 0.5 mm. A simulation program for training of the preparation was coded by the C language. In the VR world a model of upper and lower sets of teeth with a right lower first molar for preparation of crown and a lower second molar with occlusal caries for cavity preparation was arranged. The trials indicate that the VR system may be beneficial for the training and more helpful for the deal with an unforeseen situation such as sudden movement of patient occurred at random in the system.

This study was supported by the Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture in Japan (No. (A)(1)05507004).

1480 A Novel Method for the Replication of Tooth Preparations.

A.J.E. QUALTROUGH* and V. PIDDOCK (University of Manchester, UK).

Prior to this investigation, a simple means of accurately reproducing a number of *in vivo* preparations for the laboratory testing of materials or performance of restorations had not been described. In this study, a copy milling machine (Celay, Mikrona Technologie AG, Switzerland) was used to replicate *in vivo* veneer preparations onto a machinable glass-ceramic material, previously identified as having a chemical structure similar to that of hydroxyapatite. Five replicas were machined for each of thirteen preparations. Assessment of fit was selected for further investigation. Marginal fit was measured by digitising enlarged photographs, SEM studies, profilometry and by visual and tactile assessments. Overall fit was measured using an impression wash and by sectioning restored replicas after thermocycling. Inter-examiner agreement of marginal fit evaluations when clinicians used both visual and tactile assessments was generally poor. Mean marginal resin composite lute widths of replica specimens measured on enlarged photographs ranged from 0.12mm to 1.42mm. The overall thickness of a silicone fit check material for the replica restorations ranged from 168μm to 271μm with a mean value of 217μm. Examination of sectioned replicas indicated lower mean values for overall fit compared with the impression wash method, but the sites of greatest misfit tended to occur at the margins. It was concluded that this innovative machining technique provided a reliable means of replicating veneer preparations and that the method would also be applicable to other preparation types. Natural tooth tissue could also be utilised as an alternative substrate.