361 Contact Fatigue Thresholds and Strength Degradation in Dental Ceramics.
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Four classes of dental ceramics-porcelain, fine-grained micaceous glass-ceramics, infiltrated alumina and zirconia-exhibit cracking, fretting and significant strength degradation after multi-cycle contact damage in water. The threshold number of cycles required for strength-degrading damage decreases as the contact load increases. This relationship is different for each class of materials, and is critical for prediction of lifetime characteristics of these materials. For example, fine-grained glass-ceramics exhibit significant strength degradation after contact fatigue at loads as low as 200N, showing a potential for clinical failure in posterior oral regions. More damage-tolerant materials, such as zirconia, can withstand at least 10^6 cycles at a load of 500N without any strength degradation. In order to illustrate the safe regions for use of these materials, design maps have been developed which illustrate and compare single-cycle and contact fatigue responses under loads ranging from 100 to 3000N, at up to 10^6 cycles in water in relation to loads experienced in oral function and post-indentation strength requirements. Supported by a grant from NIDR, P01DE10976.

362 Strengthening of a Dental Ceramic by Microwave Ion-Exchange.
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Our aim was to investigate the effect of microwave-assisted ion-exchange on the flexural strength of a dental ceramic Discs of Optec HSP (1 3 mm thick, 16 mm diameter) were processed according to manufacturer's recommendations Nine groups (n=12) were ion-exchanged with potassium nitrate in a commercial microwave oven One group was left untreated as control, another control group was ion-exchanged with potassium nitrate in a muffle furnace at 450°C for 30 minutes The discs were fractured in water on a ball-on-ring biaxial fixture at 0 5 mm/min cross-head speed

Group	Heat treatment	Oven type	Flexural strength (MPa)
1	none	none	92.0 ± 5.1
2	Power 100% 5 minutes	Microwave	96 0 ± 22.8
3	Power 100% 4 minutes	Microwave	99.8 ± 12.8
4	Power 100% 3 minutes	Microwave	115 9 ± 21 0
5	Power 100% 2 minutes	Microwave	120.8 ± 14.5
6	Power 70% 2 minutes	Microwave	123.4 ± 23.5
7	Power 100% 30 sec	Microwave	124.8 ± 22.2
8	Power 100% 1 minute	Microwave	125.8 ± 25 6
9	450°C/30 minutes	Muffle furnace	128 0 ± 11 5
10	Power 80% 2 minutes	Microwave	128.1 ± 26 0
11	Power 90% 2 minutes	Microwave	134.8 ± 17 1

ANOVA and Tukey's test showed that the mean flexural strengths of groups 5 through 11 were not significantly different than that of the group treated for 30 minutes in a conventional muffle furnace, but significantly higher than that of the untreated control group. Microwave-assisted ion exchange can significantly reduce the time needed for strengthening of dental ceramics

363 The Flexural Strength of Ceramics Processed using Different Press Furnaces
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The aim of the study was to test the biaxial flexural strength of Optimal shaded ceramics (Jeneric Pentron) processed using different press furnaces Forty disc specimens (14 x 2mm) were sprued, invested and preheated according to the manufacturer's instructions Specimens were pressed using Optimal shaded ceramics in both the EP500 press furnace (Ivoclar-Vivadent, group 1) or the Optimal autopress (group 2) at the recommended pressing cycle and a pressing temperature of 1165°C. After divesting, samples were lapped through to 800 grit silicon carbide paper, cleaned and subjected to the following recommended firing schedules, 2 incisal, 1 stain and 1 glaze firing Twenty disc specimens *per* test group were tested using the biaxial flexure test (ASTM F394-78) in a universal testing machine at a crosshead speed of 0 15mm/minute. Mean biaxial strengths (MPa ± SD) were: group 1 132 8 ± 18.0; group 2 139.7 ± 14 4 No statistical strength difference was indicated when a t test was carried out (p>0 05) Weibull m values were group 1 8 5 and group 2 12 6 Weibull m values were not significantly different when compared for the overlap of their confidence intervals at the 95% level 1% and 5% probabilities of failure (MPa) were group 1 100 8, 114.7 and group 2 81.4, 98 7 Characteristic strength values were group 1:140 3 and group 2 145.1 X ray diffraction indicated the presence of tetragonal leucite in both test groups. The Optimal shaded ceramic may be processed in either the EP 500 or the Optimal autopress furnace without any biaxial flexural strength difference.

364 Biaxial flexure strength of feldspathic porcelains dispersed with cubic leucite.
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Our previous studies reported that cubic and tetragonal leucite were quantitatively analyzed in commercial dental porcelains. The purpose of the present study was undertaken to investigate the influence of cubic leucite on mechanical properties of dental porcelains through biaxial flexure test. The cubic leucite, stabilized by incorporation of Cs as substitution for K, was prepared from the mixture of $KHCO_3$, Al_2O_3, SiO_2, and Cs_2CO_3 by firing at 1550°C for 8 hr. A feldspathic glass matrix was prepared from the mixture of $KHCO_3$, Al_2O_3, SiO_2, and Na_2CO_3 by firing at 1450°C for 3 hr After pulverization of these fired bulks, the cubic leucite and the glass powder were characterized by X-ray diffractometry The mixtures of 5, 10, 20, and 30 wt% of cubic leucite to the glass powders were prepared. A slurry of the porcelain powder was vibrated and condensed into a mold 16 mm in diameter and 2 mm in depth The disks were fired at 900, 1000, and 1100°C for 0, 1, and 2 min using a vacuum furnace. After polishing, biaxial flexure strength of these disk specimens were determined by a piston on three ball-method. Biaxial flexure strength for the specimens containing 5, 10, 20, and 30 wt% of cubic leucite were 33.2±8.1, 33.5±7.6, 33.2±7.3, and 34.2±8.5 MPa, respectively. There were no significant differences in the biaxial strengths of the fired specimens dispersed with cubic leucite ($p<0.05$) It is concluded that the dispersion of cubic leucite has little effect on the flexure strength of feldspathic dental porcelains.

365 Influence of Specific Surface Layer on Deflection of a Glass-ceramic.
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It was reported that a specific surface layer was recognized not only in Dicor glass-ceramic but in another mica-based glass-ceramic, OCC (Olympus Optical Co., Japan). The layer in OCC mainly consisted of bar-shaped crystals, and refractory materials in OCC investment. The layer was supposed to appear due to OCC investment that could not be removed from the glass surface by 50 μm glass beads sand-blasting. The crystals were larger than the original crystals of OCC. It could be considered that deflection was induced when crystals having different sizes grew in a glass during thermal treatment for crystallization. The objective of this study was to investigate whether the deflection would be induced under the existence of the layer. Fourteen plates (2x4x20 mm) of OCC glass were cast and divested using the sand-blasting. The specimens were randomly divided into two groups. Treatments for the groups were: Group 1: all planes of each specimen were treated with rotary cutting instruments and SiC papers for complete removal of the investment; Group 2: the planes except a top 4x20 mm were treated for the removal. The deflections (D1) of the specimens were measured using a profile projector. The specimens were then crystallized according to the manufacturer's instruction, and the deflections (D2) were measured again. Resulting data for the two groups were statistically analyzed by one-way ANOVA and Fisher's PLSD ($p<0.01$). Means ± standard deviations were: Group 1: 6 ± 8 μm for D1 and 6 ± 10 μm for D2 ; Group 2: 6 ± 8 μm for D1 and -97 ± 26 μm for D2. The means in Group 1 were not significantly different, however, a significant difference was recognized between the means for D1 and D2 in Group 2. It was concluded that the specific surface layer induced the deflection in the mica-based glass-ceramic.

366 Surface Roughness and Flexural Strength of Laminated In-Ceram/Vitadur Alpha Porcelain
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A great deal of controversy exists concerning the best methods for reducing surface roughness, and improving the strength of porcelain restorations Therefore, 90 laminated In-Ceram/Vitadur Alpha (Vita) self-glazed porcelain discs were fabricated and randomly divided into three groups (n=30 each) Group 1 consisted of 30 of the original discs Six operators then polished 60 of the discs according to the recommendations of American Academy of Esthetic Dentistry. Group 2 consisted of 30 of these polished discs. The other 30 polished discs were reglazed (Group 3) Average roughness values (Ra) of the veneers were measured using a profilometer. Twenty discs in each group were then subjected to a flexure test, with either 10 of the In-Ceram cores or Vitadur Alpha veneers placed in tension The Ra values were 0 53 ± 0 07 μm (mean ± SD) for Group 1, 0 73 ± 0 27 μm for Group 2, and 0 39 ± 0.08 μm for Group 3 Following one-way ANOVA, Bonferroni's multiple comparison tests found that Groups 1 and 3 were significantly smoother than the polished group ($p<0\ 001$) Reglazed discs were significantly smoother than the original self-glazed group ($p<0\ 01$) With the veneers in tension, the flexural strengths were 150 80 ± 21 91 MPa (mean ± SD) for Group 1, 117 60 ± 22 12 MPa for Group 2, and 172.20 ± 22 12 MPa for Group 3 Following one-way ANOVA, Bonferroni's multiple comparison tests found that Groups 1 and 3 were similar ($p>0\ 05$), and significantly stronger than the polished group ($p<0\ 05$) Reglazing polished porcelain surfaces significantly improved the surface texture and physical strength of the materials tested

367 Influence of Supporting Substrate on Fracture Mode for Fluorcanasite Glass-Ceramic
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In a previous study we reported that fluorcanasite glass-ceramic (F) has a relatively high fracture toughness (≤ 5 0 $MPa{\bullet}m^{1/2}$) However, the influence of the supporting substrate properties on the fracture mode and fracture resistance has not been evaluated for this glass-ceramic system The objective of this study was to test the hypothesis that the fracture mode of glass-ceramic F is dependent on the properties of the supporting substrate material Cast glass rods were cut into disks 16 mm in diameter and 0 6 to 2 2 mm thickness Each disk was polished and sandblasted by 50 μm alumina abrasive Twenty two groups of six glass-ceramic disks each with a thickness of 0 5, 1 0, 1 5, or 2 0 mm, were bonded with Variolink® II resin cement to one of the following supporting substrates with variable elastic moduli (E) that were 18 mm in diameter and 2 mm thickness (1) group P, photoelastic resin (E = 3 1 GPa), (2) Group S, Silux Plus (E = 5 9 GPa), (3) group E, epoxy resin (E = 9 5 GPa), (4) group Z, Z100 composite (E = 12 2 GPa), and (5) group K, Ketac-Silver (E = 50 GPa) Each supporting material was bonded to four disks of different thickness (0 5, 1 0, 1 5, and 2 0 mm) Dicor glass-ceramic, bonded to Ketac-Silver, was used as the control (group DK) All of the bonded samples were supported on a flat rigid surface and loaded at the center of the ceramic with a 1 6 mm diameter pin at a cross-head speed of 0 5 mm/min until crack initiation occurred The mean failure load (F) of group K1 0 (1862 ± 298 N) was significantly greater ($p \le 0\ 05$) from the mean F value of all other groups (E1.0, P1 0, and DK1,0), and the mean F value of group E1 0 (1424 ± 91 N) was not significantly different ($p > 0\ 05$) from that of group P1 0 (1295 ± 75 N) The failure load and fracture mode were affected by the elastic modulus of the supporting substrates The low flexure strength of the group K substrate led to fracture of the substrate without any evidence of ceramic fracture We conclude that the fracture resistance of fluorcanasite glass-ceramic increases with increasing elastic modulus of the supporting substrate. This study was supported by NIH-NIDR Grant DE09307 and DE06672

368 Effect of Tempering Shoulder Porcelain in Silicone Fluids on Flexural Strength
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Tempering is used extensively in industrial applications of glass and ceramics to increase strength and enhance reliability Hojjatie and Anusavice (1993) established that air and oil tempering of dental porcelains improved resistance to crack initiation and failure This study tested the hypothesis that quenching porcelain from a temperature higher than its glass transition temperature, to 100° C in a low viscosity silicone fluid, would yield the greatest increase in biaxial flexural strength Disks (16 mm dia X 2 mm) of two shoulder porcelains (V and C) were produced according to the manufacturer's instructions and polished through 1 μm, then divided into 20 groups Three silicone fluids (Dow Corning®) 210H (F1), 550® (F2), 800™ (F3) with respective viscosities of 50 20 and 3 cs at 100° C were selected Specimens were heated to one of three temperatures, Tg (T1), Tg +50° (T2) and Tg + 100° (T3), held for three minutes and quenched Biaxial flexure testing was performed using a pin-on-three ball fixture in a universal testing machine at a crosshead speed of 0 5 mm/min Representative post-fracture surfaces for each group were examined by SEM Porcelain C specimens exhibited a "bi-modal" fracture appearance Mean biaxial flexural strength (BFS) values were calculated for each of the 20 groups BFS values ranged from 85 8 ± 5 7 MPa to 26 43 ± 8 0 MPa with control strengths of 57 0 ± 3 8 MPa for C and 53 3 ± 11 2 MPa for V Data was analyzed using the ANOVA procedure in SAS Duncan's Multiple Range test was used to compare means and Dunnett's T test for comparison against the control There was no significance at the 0 05 level between fluid (F) and temperature (T) for porcelain V However, there was a significant interaction between F and T ($p = 0\ 0424$) for the porcelain C groups Within groups F1 and F2, T1 showed a significant effect ($p = 0\ 0001$) on BFS Their mean BFS values are T1-F1 85 8 ± 5 7 MPa, T1-F2 83 4 ± 6 6 MPa The bimodal distribution in BFS is probably due to flaws produced internally which propagate to the tensile surface during tempering. Tempering porcelain C from the glass transition temperature does yield an increase in flexural strength In contrast, higher temperatures decrease the strength compared with that of control specimens Thermal tempering did not increase the strength of porcelain V This study was supported by NIH-NIDR Grant DE06672