Short Communication

Effect of 10 Years of In Vitro Aging on the Flexural Properties of Fiber-Reinforced Resin Composites

Pekka K. Vallittu, DDS, PhD, CDT[a]

This study determined the effect of 10 years of water immersion on the properties of fiber-reinforced resin composites (FRC). E-glass and silica fibers were used to reinforce heat-cured and autopolymerized acrylic resin polymers. Control specimens were unreinforced. Test specimens stored in water for up to 10 years were tested by the 3-point test. The flexural strength and elasticity of the specimens decreased during water immersion ($P < .001$, analysis of variance). After 10 years, the reductions in flexural strength and modulus of E-glass FRC were 24% and 21%, respectively; for silica FRC, reductions were 47% and 46%, respectively; and for controls, reductions were 24% and 11%, respectively. E-glass FRC showed a smaller reduction in strength than silica FRC. *Int J Prosthodont 2007;20:43–45.*

The use of fiber-reinforced composites (FRC) in dental applications has increased during recent years. In the majority of clinical applications, good long-term stability of materials in the oral environment is needed. It is known that water influences the properties of FRC by plasticizing the polymer matrix of the FRC.[1,2] In the short term (eg, 1 month), this reduction in flexural properties is reversible; dehydration of the FRC will return the material to the flexural qualities of the dry material.[3] In the longer term, resin composites reinforced with glass fibers can be prone to irreversible degradation because of surface leaching of glass fibers and hydrolysis of the siloxane network that adheres the glass fibers to the polymer matrix.[4] The chemical composition and surface treatment of glass fibers (sizing, including silanization) vary by manufacturer.[5]

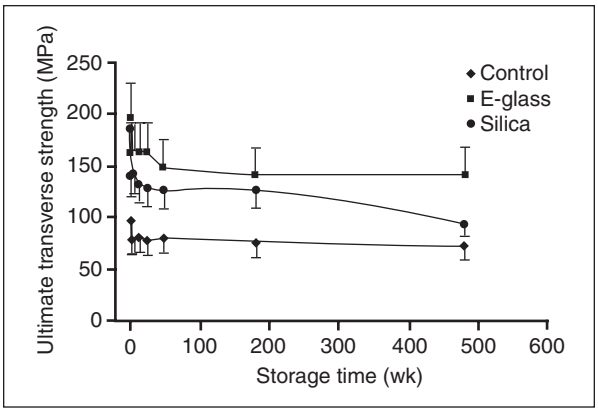
The aim of this study was to evaluate the possible long-term reductions in flexural properties of E-glass and silica FRC that had been immersed in water for up to 10 years.

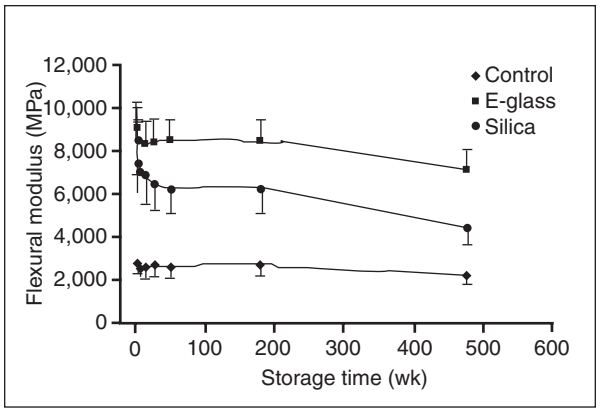
Materials and Methods

A detailed description of the materials and methods was reported previously.[1,2] Palapress Vario (Heraeus Kulzer) and SR 3/60 (Ivoclar Vivadent) were used as autopolymerized and heat-cured resin composites. Bar-shaped unreinforced (control) and fiber-reinforced test specimens (3.3 × 10.0 × 64.0 mm) (n = 6) were fabricated by layering continuous E-glass (Ahlström) or silica fiber (Enka) weaves into autopolymerizing or heat-polymerizing denture base resin (although control specimens did not include E-glass or silica). The fabrication process of the test specimens followed the technique that was state of the art in 1995. The fibers of the weaves were oriented at the angles of +45 or –45 degrees. The test specimens were stored either dry or in distilled water at 37°C for 2 weeks, 4 weeks, 12 months, 24 months, 48 months, or 120 months (10 years). A 3-point loading test was carried out in air at 23°C ± 1°C (relative humidity of 55%) for the dry specimens and in water for the water-stored test specimens. The crosshead speed of the testing device (Lloyds LRX, Lloyds Instruments) was 5 mm/min. Ultimate flexural strength and flexural modulus were then calculated.[5] Statistical analysis of the results was carried out in 2 stages with SPSS software. The values for flexural strength and modulus were compared by analysis of variance (ANOVA) within the material combination groups, followed by the Tukey post hoc test.[5]

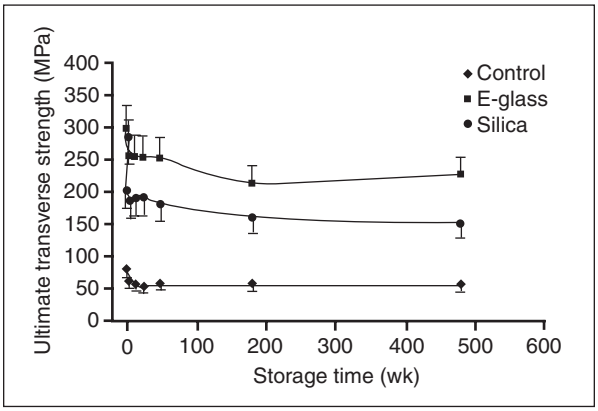
[a]*Specialist in Prosthodontics and Professor of Biomaterials Science, Department of Prosthetic Dentistry and Biomaterials Science, Institute of Dentistry, University of Turku, Finland.*

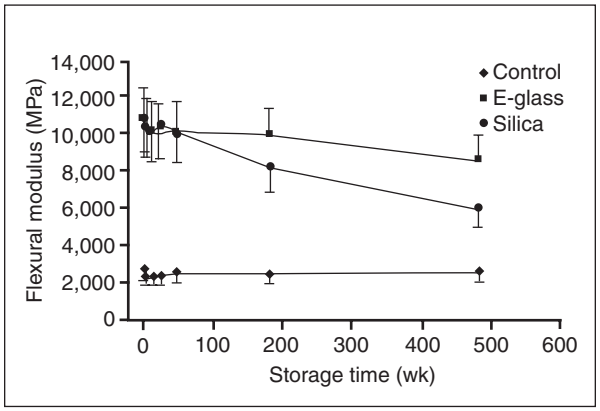
Correspondence to: *Prof Pekka Vallittu, Institute of Dentistry, Lemminkäisenkatu 2, FI-20520 Turku, Finland. Fax: +358-2-333-8390. E-mail: pekka.vallittu@utu.fi*





Figs 1a and 1b *(Left)* Flexural strength and *(right)* flexural modulus of test specimens made from heat-cured resin composite (SR 3/60), plotted against water storage time of the specimens. Vertical lines = standard deviations.





Figs 2a and 2b *(Left)* Flexural strength and *(right)* flexural modulus of test specimens made from autopolymerized resin composite (Palapress), plotted against water storage time of the specimens. Vertical lines = standard deviations.

Results

As the time in water storage lengthened, the flexural strength and flexural modulus decreased in heat-cured and autopolymerized denture base polymer, regardless of whether the material was fiber reinforced or not (Figs 1 and 2). Reductions in flexural strength after 10 years of water storage were 25% for autopolymerized E-glass FRC, 23% for heat-cured E-glass FRC, 49% for autopolymerized silica FRC, and 45% for heat-cured silica FRC. In unreinforced specimens, the autopolymerized polymer showed a 25% reduction in flexural strength, and the heat-cured polymer showed a 24% reduction in flexural strength. ANOVA showed that the reduction in flexural strength was significant ($P < .001$), and post hoc analysis revealed that significant reductions occurred during the first 4 weeks of storage, with the exception of the heat-cured silica FRC, which instead showed a constant reduction in strength over time (Fig 1a).

Flexural modulus values were reduced by 22% for autopolymerized E-glass FRC, by 20% for heat-cured E-glass FRC, by 47% for autopolymerized silica FRC, and by 45% for heat-cured silica FRC. In the unreinforced specimens, autopolymerized polymer showed a 21% reduction in flexural modulus and heat-cured polymer showed a 2% reduction in flexural modulus. ANOVA showed that the reduction in modulus was significant in E-glass and silica FRC and in unreinforced heat-cured polymer ($P < .001$) but not in unreinforced autopolymerized resin composite ($P = .421$). Post hoc analysis revealed that significant reductions in the flexural modulus of the FRC materials occurred during the entire storage time, although the greatest reductions were noticed in the first 4 weeks.

Discussion

The effect of water storage at body temperature on the flexural properties of FRC material was tested. The E-

glass fibers that were used in the study are commercially available in one dental FRC brand (everStick, Stick Tech), and the silica fiber was an experimental material with known good hydrolytic stability. The results showed that whereas the silica fibers as such are stable, the long-term stability of a resin composite that is reinforced with silica fibers may not be good. On the other hand, the E-glass, with its known susceptibility for poorer hydrolytic stability than silica fibers, provided better long-term stability as a resin composite reinforcement. In fact, no reduction in flexural strength occurred after 4 weeks of storage with E-glass. Thus, the results suggest that the E-glass fibers with this particular glass composition and surface sizing provided stable FRC over a span of 10 years.

References

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Literature Abstract

Comparison of repair methods for ceramic-fused-to-metal crowns

This study evaluated the effect of 4 repair methods on the final fracture loads of ceramic-fused-to-metal (CFM) crowns repaired with resin composite and various surface conditioning methods. Maxillary right central incisor CFM crowns were fabricated by a single dental technician and then cemented to metal dies with resin-based cement. The crowns were subsequently fractured with a loading machine and 4 experimental treatment groups were prepared (n = 9): *(1)* 9.5% hydrofluoric acid etching for 90 seconds, *(2)* air-particle abrasion with 50-µm alumina particles, *(3)* silica coating, and *(4)* application of 2 layers of E-glass fiber-reinforced composite (FRC) on the repair surface of the crown. Repair of the crowns following surface conditioning were completed using resin composite in an incremental build-up technique. The test specimens were then stored in water at 37°C for 24 hours and then subjected to thermocycling for 6,000 cycles. After thermocycling, the specimens were loaded until catastrophic failure. Specimens were visually examined for failure type and location. One-way analysis of variance (ANOVA) and the Bonferroni test were used to evaluate the failure load between the test groups. No statistically significant differences in failure load were noted between groups 1 (376 ± 155 N), 2 (432 ± 132 N), and 3 (582 ± 127 N) ($P > .05$). There was a significantly higher failure load with the use of an FRC layer (885 ± 123 N) compared to other test groups ($P < .0001$). There was no statistically significant difference between the failure load of intact crowns (872 ± 459 N) and FRC-repaired crowns ($P > .05$). Adhesive failures at the alloy-veneering resin interface occurred most frequently in group 1, while groups 2 and 3 showed more cohesive failures within the veneering resin. The FRC group showed exclusively cohesive failures between the 2 FRC laminate layers. The limitation of this study was that the test specimens were subjected to repair cycles where the conditioning methods were applied in changing order. Thus, there were changes in the repair surface areas following each fracture test and repair cycle.

Özcan M, van der Sleen JM, Kurunmäki H, Vallitu PK. *J Prosthodont 2006;*15:283–288 **References:** 28. **Reprint:** Dr Mutlu Özcan, University of Medical Sciences, University of Groningen, Department of Dentistry and Dental Hygiene, Antonius Deusinglaan 1, 9713 AV Groningen, The Netherlands. E-mail: mutluoczan@hotmail.com—*Elvin W.J. Leong, Singapore*