Short Communication

Effect of Relative Humidity on the Hydrophilicity of Unset Elastomeric Impression Materials

Frank Rupp, MSc, PhD[a]/Detlef Axmann, MSc, PhD[b]/Jürgen Geis-Gerstorfer, MSc, PhD[c]

This study aimed to analyze the effect of relative humidity (RH) on the initial hydrophilicity of unset elastomeric dental impression materials. Initial water contact angles were studied on thin unset films of 1 polyether and 4 polyvinyl siloxane (PVS) impression materials at 20%, 50%, and 80% RH by high-resolution drop shape analysis. One of 4 PVS materials reached the polyether's initial hydrophilicity. This PVS showed increased hydrophilicity with increasing RH. The initial hydrophilicity of impression materials can be influenced by the RH level. Accounting for RH will enhance the clinical relevance of hydrophilicity studies. *Int J Prosthodont 2008;21:69–71.*

The hydrophilicity of elastomeric impression materials during setting has attracted increasing interest in recent years. Hydrophilicity is attributed to optimized flow properties and accurate detail reproduction at the time of clinical application, especially on wet oral surfaces. Current methods to quantify hydrophilicity are based on contact angle calculations by high-resolution drop shape analysis.[1–5] Measurements have been taken after the start of impression material mixing to characterize the wetting properties within the respective working times.[1,4] Since the first contact of the impression material with wet oral hard and soft tissues is clinically regarded as the most important, that contact is predominantly characterized in terms of initial hydrophilicity of thin impression material films. Until now, such experiments have been performed under ambient atmospheric conditions. Since the influence of the moist oral atmosphere on initial hydrophilicity is unknown, the objective of this study was to analyze the effect of different relative humidity (RH) levels on initial water contact angles of a range of elastomeric impression materials by means of a climate chamber.

Materials and Methods

Five type 3 impression materials—4 polyvinyl siloxanes (PVS) and 1 polyether—were included in this study (Table 1). The materials were mixed and syringed according to the manufacturers' instructions at 23°C (room temperature). Fifty-µm material films were prepared using a metal mold. Eight-µL water drops (Millipore) were video-recorded (25 frames/second) during an evaluation period of 3 seconds using the Drop Shape Analysis System (DSA10-MK2, Kruess). The experimental setup was described previously.[4] The first second of the water/material contact was chosen to characterize the initial hydrophilicity by circle-fit calculation of the respective left and right contact angles of each drop shape using the analytical software DSA1 (Kruess). The RH during all measurements, starting 30 seconds after mixing of the impression materials, was kept constant at 20%, 50%, or 80% using the climate chamber TC 40 (Kruess). In addition, a series of measurements was carried out 60 and 90 seconds after mixing at 80% RH. Each experiment was conducted fivefold. Two-way analysis of variance (ANOVA) was applied to identify main and interaction effects of the factors "material" and "RH" and "material" and "time after mixing" on the dependent variable "contact angle," followed by Tukey honestly significant difference (HSD) post hoc test for pairwise comparisons (JMP 5.0.1.a, SAS Institute).

---

[a] Research Associate, Department of Prosthodontics and Section Medical Materials and Technology, University Hospital Tuebingen, Germany.

[b] Mathematician, Department of Prosthodontics and Section Medical Materials and Technology, University Hospital Tuebingen, Germany.

[c] Professor and Head of Section Medical Materials and Technology, Department of Prosthodontics, University Hospital Tuebingen, Germany.

Correspondence to: *Dr Frank Rupp, University Hospital Tuebingen, Department of Prosthodontics, Section Medical Materials and Technology, Osianderstr. 2-8, D-72076 Tuebingen, Germany. Fax: 49 7071 29 5775. E-mail: frank.rupp@med.uni-tuebingen.de*

Table 1 Elastomeric Impression Materials Used in the Study

Impression material	Abbreviation	Polymer type	Manufacturer	Batch no.
Affinis light body	AFF	PVS	Coltène/Whaledent	0059807
Aquasil Ultra XLV	AUX	PVS	Dentsply DeTrey	050829
Panasil contact plus	PCP	PVS	Kettenbach	60581
Panasil initial contact X-light	PIC	PVS	Kettenbach	60041
Impregum Garant L DuoSoft	IGL	Polyether	3M ESPE	242647

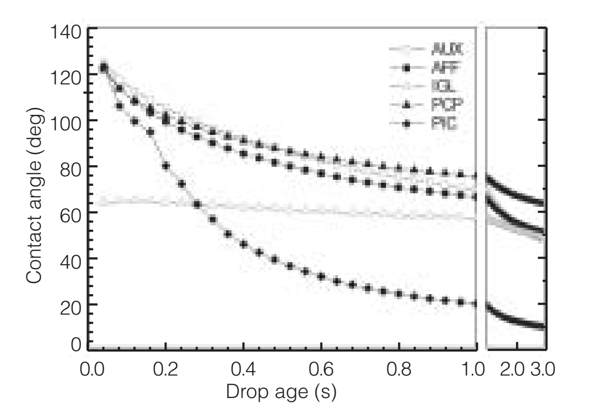

Fig 1 Mean initial contact angles during the first 3 seconds of water/impression material contact.

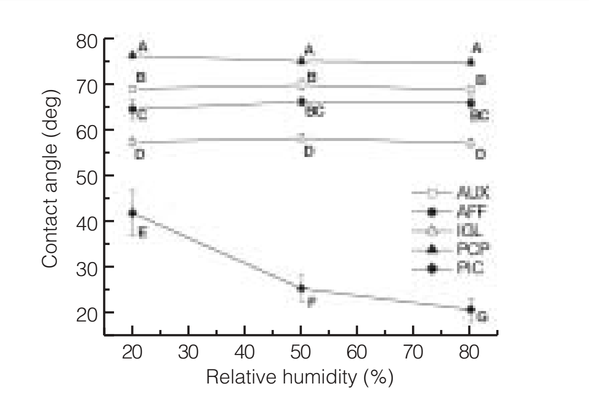

Fig 2 Mean contact angles and SDs at a drop age of 1 second as a function of relative humidity 30 seconds after mixing. Means not connected by the same letter are significantly different (Tukey HSD, $\alpha = .05$).

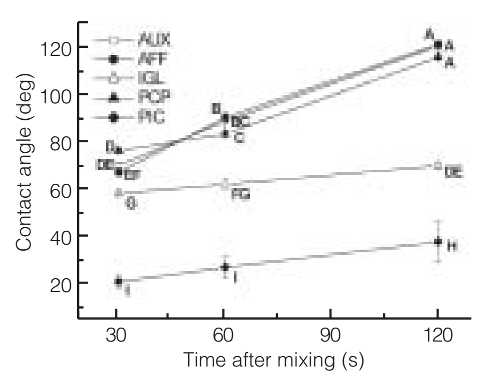

Fig 3 Mean contact angles and SDs at a drop age of 1 second as a function of time after mixing at 80% relative humidity. Means not connected by the same letter are significantly different (Tukey HSD, $\alpha = .05$).

Results

Figure 1 shows the initial mean contact angles during the first 3 seconds of water contact (30 seconds after mixing, 80% RH). Throughout the evaluation period, the polyether IGL showed constant contact angles, whereas all PVS materials were characterized by hydrophilization. The PVS materials did not reach the polyether's hydrophilicity after 1 second, with the exception of PIC, which showed the strongest hydrophilization. PIC equaled the IGL contact angles at a drop age of 0.28 seconds and reached contact angles of 19 degrees after 1 second and < 10 degrees after 3 seconds. Figures 2 and 3 show the mean contact angles and SDs of 1-second-old drops as a function of RH and time after mixing, respectively. Qualitatively, with increasing RH, PIC became more hydrophilic, whereas the contact angles of all other materials were more constant (Fig 2). The initial hydrophilicity of all materials at 80% RH was reduced during setting (Fig 3).

The ANOVA showed statistically significant main and interaction effects ($P < .05$). Thus, post hoc Tukey HSD ($\alpha < .05$) was applied and showed statistically significant differences between all materials, between all RH level means, and between all time after mixing means, with the exception of the material pairs AUX/AFF and AUX/PCP. Interaction effects are visualized in Figs 2 and 3. Only PIC and RH showed an interaction based on statistically significant mean differences at all 3 RH levels. Differences in the mean contact angles of every material were statistically significantly dependent on the time since mixing.

Discussion

Decreasing contact angles, generally observed with unset hydrophilized PVS materials as a function of the drop age, can be explained by the impact of surfactants. RH values of 50% were chosen to simulate the RH level of the ambient room, 80% to simulate the oral cavity, and 20% to simulate a very dry situation. Analyzing the initial contact angles of 1-second-old drops at 20%, 50%, and 80% RH, the PVS PIC is more hydrophilic than the polyether. In contrast to the material's main effect, the main effect of RH is not consistent but rather is based on the PIC/RH interaction. Regarding the factor "time after mixing," the differences between the contact angles were statistically significant with increased contact angles and increasing time, at least at one time point for a given material, indicating consistency. Decreased hydrophilicity with ongoing working time may be a factor that negatively influences clinical impression results.

Conclusion

To the authors' knowledge, this study has shown for the first time that the RH level can influence the hydrophilic behavior of impression materials. Contact angle analyses that account for RH will identify impression materials sensitive to RH and lead to more clinically relevant data. Until now, the term *initial hydrophilicity* has not been clearly defined. Therefore, it must be taken into consideration that the degree of initial hydrophilicity or rankings between materials may differ, depending on the frame rate of the analysis system and on the drop age from which the contact angle is taken.

Acknowledgments

The authors thank Kettenbach for its support of this study.

References

1. Rupp F, Jacobi A, Groten M, Geis-Gerstorfer J. Hydrophilic changes characterizing the working time of different elastomeric impression materials [abstract]. J Dent Res 2002;81:1204.
2. Mondon M, Ziegler C. Changes in water contact angles during the first phase of setting of dental impression materials. Int J Prosthodont 2003;16:49–53.
3. Eichhorn M, Balkenhol M, Ferger P, Wöstmann B. Wettability of newly introduced PVS-materials [abstract]. J Dent Res 2005;84:1898.
4. Rupp F, Axmann D, Jacobi A, Groten M, Geis-Gerstorfer J. Hydrophilicity of elastomeric non-aqueous impression materials during setting. Dent Mater 2005;21:94–102.
5. Kugel G, Klettke T, Goldberg JA, Benchimol J, Perry RD, Sharma S. Investigation of a new approach to measuring contact angles for hydrophilic impression materials. J Prosthodont 2007;16:84–92.

Literature Abstract

Resin elasticity and the strengthening of all-ceramic restorations

The purpose of the study was to investigate the strengthening effect of resins with different elastic behaviors in a simulated resin-bonded all-ceramic restoration. The hypothesis was that ceramic strength enhancement is dependent on the elastic modulus of the resin cement selected. Two hundred forty porcelain disks were prepared using Vitadur-Alpha dentin porcelain powder and modeling fluid. The specimens were vacuum-fired according to the manufacturer's instructions and air abraded with 50-µm alumina particles. One group served as the control while 3 other groups were coated with 120 ± 20 µm of 3 different resins (Flowline, Rely-X Veneer Cement, and Clearfil APX). A profilometer was used to characterize the surface texture of the porcelain control surface. Three readings were taken across the center of each specimen. Each specimen was subjected to biaxial flexure testing. Multiple comparisons of the 3-point and biaxial group means were made by a 1-way analysis of variance and Tukey multiple range tests at $P < .05$. The biaxial flexural strength data were ranked in ascending order. A Weibull analysis was performed and 95% confidence limits were considered to be significant. The results indicated that all resins significantly increased in mean strength, and this increase was associated with the elastic modulus of the resin ($R^2 = 0.9885$). The author concludes that the hypothesis was accepted and explained that the combination of Poisson constraint and the creation of a resin-interpenetrating layer sensitive to the elastic modulus may be responsible for the strengthening mechanism.

Addison O, Marquis PM, Fleming GJP. *J Dent Res* 2007;86:519–523. **References:** 29. **Reprints:** Dr O. Addison, Biomaterials Unit, School of Dentistry, University of Birmingham, St Chad's Queensway, Birmingham B46NN, UK. E-mail: addisonobham.ac.uk—*Beatrice Leung, Toronto, ON*