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ORIGINAL ARTICLE

Grander system: A new technology to reduce surface tension of adhesive systems in dentistry

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Abstract

Background. Reduced surface tension of liquids results in higher surface wetting ability and diffusivity by the substrate. ***Objectives.*** The objective of this study was to evaluate the influence of the Grander Technology in reducing the surface tension of adhesive systems. ***Methods.*** Two adhesive systems (self-etch and total-etch) were modified by physical contact with the Grander system Flexible unit to revitalize water, for 48 h. Surface tension of adhesive systems and water in normal and grander-modified conditions was measured with a goniometer. ***Results.*** The results showed a reduction of surface tension for all conditions grander-modified between 3–15%. ***Conclusions.*** Grander Technology was effective in reducing the surface tension of the Single Bond and Clearfil SE Bond adhesive systems. ***Clinical significance.*** Grander technology was employed to restructure the molecular structure of water-based adhesive systems, which can increase their wetness capacity and therefore ensure a greater diffusibility.

Key Words: *grander technology, surface tension, total-etch adhesive systems, self-etch adhesive systems*

Introduction

Adhesion of filling materials to enamel and dentin is today one of the most frequent procedures in clinical practice. However, it still represents the weak link of the longevity of composite restorations, since over 50% of these restorations are lost by adhesive failures in less than 8 years after its placement [1–3].

The total-etch and self-etch adhesive systems exhibit distinct differences in composition and physicochemical properties, providing significant differences in the quality of hybridization.

The hybrid layer is directly related to the treatment of the substrate and to the intrinsic characteristics of adhesive systems. On one hand, the dentine acid etching produces deep changes in chemical composition and physical properties of its matrix and these can influence the quality of union between dentin–resin and its resistance and durability [4–6]. On the other hand, the surface wetting ability, an intrinsic factor of the adhesive systems determined by its surface tension, directly influences the quality of the adhesion according to the modified diffusivity of the substrate [7].

The total-etch adhesive systems effectiveness depend on a critical control of the substrate for bonding to dentin. The maintenance of dentin humidity after acid etching is a factor that contributes to hybridization failures, because it is complicated to determine the exact humidity of the dentin for the best bonding results; for its dryness results in the collapse of collagen fibers and its excessive humidity dilutes the monomers affecting achieving a satisfactory hybridization. Also, the possibility of failures in hybrid layer formation can be promoted by the factors, such as: moisture, washing, drying, amount of deposited product, application form, waiting time and polymerization characteristics [8–13].

The self-etch adhesive systems are highly hydrophilic, which makes them compatible with a moist

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substrate. However, they have their durability compromised due to their high permeability to the moisture of the substrate and the oral environment [14,15]. These adhesive systems work with a simplified technique and need less humidity control, because here the washing step is eliminated, since the substrate conditioning is performed simultaneously with the primer application. Another advantage is the elimination of the weak zone, a region susceptible to degradation over time due to the unprotected collagen by the adhesive [16–21].

These two adhesive systems show also differences in viscosity and, therefore, flow differently on the tooth surface. Adhesive systems that have primer and bond in a single-bottle present intermediate visual viscosity when compared to adhesive systems that have primer and bond divided into two-bottles.

Searching for answers, we encounter a new possibility for the stabilization of adhesion, not yet researched in dentistry: Grander Technology. Johan Grander is an Austrian researcher, who developed a method to revitalize water by physical spatial restructuring of its molecules. This restructuring allows a molecular balance with improved transportation properties [22], probably by reducing its surface tension [23].

By extrapolating the water revitalization process for the ideal conditions in terms of adhesiveness, we could modify an adhesive system, also a liquid with an aqueous solvent, to provide a reduction in surface tension, increasing its wetness capacity and therefore ensuring a greater diffusibility.

The objective of this study was to evaluate the immediate influence of Grander Technology in the surface tension of total-etch and self-etch adhesive systems. The null hypothesis tested was that the Grander Technology cannot change the surface tension characteristics of the adhesive systems.

Materials and methods

Modification of adhesive systems and water Grander System

The first step required for the execution of the entire methodology was the modification of the Adpler Single Bond (3M ESPE, St. Paul, MN) and Clearfil SE Bond (Kuraray Medical Inc., Okayama, Japan) adhesive systems and the water by the Grander System:

- *Experimental*: Two sets of the same batch of each adhesive system were used. One set was kept unchanged and the other was placed in physical contact with the Grander System Flexible Unit (Grander Technologies, Jochberg, Austria). This system consists of a device named Flexible unit, capable of revitalizing waters by electromagnetic induction of molecular rearrangement through contact with bottles of liquids or by the passage of liquids through the interior of channels placed among cylinders that build the core of the unit. Thus, the bottles of adhesive systems were placed in contact with the unit flexible for 48 h.
- *Control*: Two bottles with 5 ml of distilled water were revitalized by the grander system for 48 h, following the same treatments described above.

Surface tension measurement. For surface tension measurement, eight groups were established:

- Group 1: distilled water (control);
- Group 2: Grander-modified distilled water (experimental);
- Group 3: Single Bond total-etch adhesive system (control);
- Group 4: Grander-modified Single Bond total-etch adhesive system (experimental);
- Group 5: *primer* Clearfil SE Bond self-etch adhesive system (control);
- Group 6: Grander-modified *primer* Clearfil SE Bond self-etch adhesive system (experimental);
- Group 7: *bond* Clearfil SE Bond self-etch adhesive system (control);
- Group 8: Grander-modified *bond* Clearfil SE Bond self-etch adhesive system (experimental).

Surface tension of each group was measured by automatic goniometer (Ramé-Hart Instrument Co. 0.100-00, Washington DC). Temperature and moisture conditions of the environment were controlled at 23°C and 50% RH, respectively.

Samples were collected from each group on a micro-syringe (Gilmont, Barrington, IL). The micro-syringe presents a micrometer Teflon, a glass barrel, a rubber sealing ring and a metallic needle number 22. The barrel was wrapped in aluminum foil in order to prevent adhesive systems polymerization in its interior, due to the room light. The whole set was fixed in the goniometer support to measure the surface tension.

By turning the micrometer screw clockwise by hand, a gradual drop of liquid was obtained, which remained attached to the needle tip due to its surface tension. The device allows adjustment of the number of steps/time. Twenty measures were taken for every drop of each liquid tested, yielding a mean value of measured surface tension.

Data were submitted to the two-way ANOVA (liquid and procedure factors) followed by the Tukey test, at a 5% level of significance.

Results

The surface tension means are listed in Table I. For liquid factor, ANOVA showed a p-value = 0.0001 (F = 72,083.52), with 3degree of freedom. The

Table I. Mean (standard-deviation) of the surface tension (D/cm) for different liquids and procedures.

	Procedure	
Liquids	Control	Experimental (Grander-modified)
Water	80.94 (1.52)	72.11 (0.50)
Bond Clearfil SE Bond	31.10 (0.46)	29.25 (0.26)
Primer Clearfil SE Bond	35.13 (0.29)	34.08 (0.27)
Single Bond	27.77 (0.28)	23.61 (0.23)

ANOVA showed a p-value = 0.0001 (F = 2612.66), with 1° of freedom for procedure factor. The ANOVA showed a p-value = 0.0001 (F = 31,261.63), with 3° of freedom for interaction between factors.

Table II shows the results of Tukey's test for procedure factor. The Grander-modified experimental group showed significant reduced surface tension compared to the control group.

Table III shows the results of Tukey's test for liquid factor. The single Bond total-etch adhesive system showed significant lowest surface tension compared to the *primer* and *bond* Clearfil SE Bond self-etch adhesive system and water. Water showed the highest surface tension compared to total-etch and self-etch adhesive systems.

Table IV shows the results of Tukey's test for interaction between factors. All experimental groups showed significantly reduced surface tension compared to control groups.

Discussion

The purpose of this study is very interesting and new in dentistry. The modification of an adhesive system by a physical process of molecular rearrangement, done either by the professional researcher or by the manufacturer, opens new possibilities for researches to the adhesion stability. As the modification of the adhesive systems by Grander technology has never been used for this purpose, a study was first needed to verify if the desired changes would occur in the adhesive systems before carrying out studies to verify its influence on the longevity of the adhesion of composite restorations.

Table II. Tukey's test results for liquid factor (D/cm).

Liquid	Mean	Homogeneous sets*
Water	1.8830	A
Primer Clearfil SE Bond	1.5391	B
Bond Clearfil SE Bond	1.4795	C
Single Bond	1.4084	D

* The groups accompanied by the same letters presented no significant differences.

Table III. Tukey's test results for procedure factor (D/cm).

Procedure	Mean	Homogeneous sets*
Control	1.5957	A
Grander-modified	1.5574	B

* The groups accompanied by the same letters presented no significant differences.

As a first step of this new line of research, we tried to verify changes in the liquids when in contact with the Grander system Flexibe unit. Faissner [20] evaluated all the properties (ionic balance, density, conductivity, pH, surface tension, alcohol test, liquid phase equilibrium/steam and boiling diagram) of water (control) and water Grander-modified (experimental) and found that the surface tension was the one with the most significant change, ~10%, compared to the others properties analyzed.

On the surface of liquid and solid, atoms and molecules have higher energy than those located inside. For the liquids, this energy is called surface tension. This is because the molecules on the surface are more distant from each other due to the loss of molecules by evaporation, leading to greater intermolecular attraction energy. This situation results in a surface contraction force on the surface, which creates a surface film resistant to any extension or penetration [7].

In agreement with Faissner [20], in this study, the surface tension of water exhibited significant reduction (~11%) when subjected to the modification by the Grander system, according to Table I (from 80.94 D/cm to 72.11 D/cm).

The null hypothesis was rejected for surface tension, because the Grander system reduced the surface tension of water and the liquids tested (*Primer* and *Bond* Clearfil SE Bond and Single Bond adhesive systems), but in different percentages for each system, according to Tables I and II, probably due to the

Table IV. Tukey's test results for interaction between the factors (D/cm).

Liquid	Procedure	Mean	Homogeneous sets*
Water	Control	80.935	A
Water	Experimental	72.106	B
Primer Clearfil SE Bond	Control	35.130	C
Primer Clearfil SE Bond	Experimental	34.08	D
Bond Clearfil SE Bond	Control	31.102	E
Bond Clearfil SE Bond	Experimental	29.253	F
Single Bond	Control	27.774	G
Single Bond	Experimental	23.613	H

* The groups accompanied by the same letters presented no significant differences.

differences in water content of each of them or by the greater molecular complexity of these liquids.

The reduced surface tension is reflected in a greater ability of the liquid to wet the substrate and, thereby, improve its diffusibility and consequent adhesion [24,25].

According to Wang et al. [25], it can be speculated that differences in composition and concentration of solvents could affect the penetration of adhesive bonding agents and introduce differences in the structure of the bond formed at the adhesive/dentin interface.

The adhesive systems were activated by the Grander unit for 48 h according to the manufacture directions, this being the time for the molecular restructure to occur. The Single Bond total-etch adhesive system presents water and ethanol as solvents in their composition. Theoretically it would be changed by the Grander technology. According to the results of surface tension, this adhesive system showed the highest change after the Grander procedure had been performed (from 27.77 D/cm to 23.61 D/cm) compared to other adhesive systems. This adhesive system presents the *primer* and *bond* in a single-bottle and has higher viscosity compared to the Clearfil SE Bond self-etch adhesive system primer. Visually the Single bond adhesive system became more flowable after the Grander modification.

The Clearfil SE Bond *Primer* also contains water and ethanol as solvents in the composition. However, the liquid by itself is very fluid and a visual distinction before and after Grander modification was not possible, although the reduction in surface tension was statistically significant (from 35.13 D/cm to 34.08 D/cm).

The Clearfil SE *Bond* has no water in its composition, according to the manufacturer, but has ethanol. Despite significant reduction in surface tension (from 31.10 D/cm to 29.25 D/cm), no visual change in viscosity of the liquid was observed after the Grander modification.

Ethanol has a reduced surface tension compared to water [26]. The surface tension of the ethanol present in the composition of the adhesives may too have exhibited surface tension reduction when the adhesives were subjected to the modification by the Grander system, therefore contributing also to the significant reduction in surface tension of the adhesives tested.

An important practical observation is that the adhesive systems already have a reduced surface tension compared to water (water: 80.94 D/cm; adhesive systems: from 27.77 D/cm to 35.13 D/cm). This reduced surface tension brings an extreme difficulty in measuring the surface tension, where drops of Grander-modified systems were always more difficult to control because they slid more easily by the needle of the goniometer.

The software of the goniometer has a tool to frame the drop, which helps to control its volume, because the actuation for measurements only occurred when the drop was properly framed.

The dental literature is limited on the surface tension of adhesive systems and this shortage generated this particular curiosity. Papers in the physics and chemistry area show various research, but they represent the data from the different materials than the ones used in dental practice, which prevents comparisons.

Further research is needed to compare the surface tension of polar and non-polar liquids of known density in Dentistry, as well as comparisons among other adhesive systems and should include the adhesive/dentin bonding analysis.

Conclusion

Based on the methodology employed, it can be concluded that the Grander Technology reduced the surface tension of the adhesive systems tested, promising to improve the penetration and wetting of substrates by the adhesive systems.

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