Contact Angle Wettability Semi-Quantitative Assessment after Titanium Surface Modification

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Introduction

- Throughout the past decade, implant restorations for missing teeth have become increasingly more common. Following implant placement, gingival recession and bone loss can lead to unfavorable functional and aesthetics outcomes and may require soft tissue grafting procedures with unpredictable clinical outcomes.
- The success of these soft tissue grafting procedures has been strongly linked to stabilization of the grafting membrane. This stability can be increased by increasing the adhesive forces between the implant and the grafting material.
- Contact angle goniometry (*Figs. 1 and 2*) is used to measure where the liquid/vapor interface meets a solid surface. This contact angle is directly related to a surface's wettability, free energy and adhesiveness[1].
- This measurement gives insight into the effectiveness of different surface treatments (*Fig.3*) on soft tissue grafting procedures success.

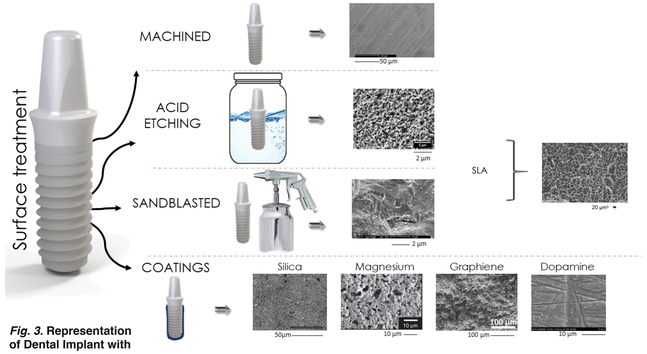


***Fig. 3.* Representation of Dental Implant with Different Surface Treatments.** Different treatments to dental implants can be seen with SEM imaging of the surfaces along with different coatings that can be applied to the titanium[2,3]

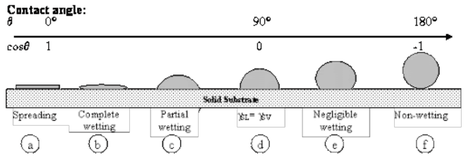
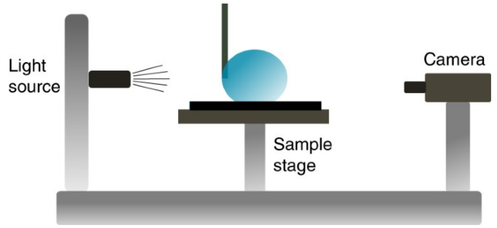


***Fig. 1.* Comparison of Different Contact Angle Measurements and Surface Wettability.** Various contact angle measurements with relative wetting of the solid substrate can be seen in the figure above. The degree of wettability of the surface can be measured by the angle between the droplet and the surface.

Methods

- Three sets of titanium surfaces (machined "M", sandblasted "SA" and sandblasted, large grit, acid- etched "SLA") were prepared to model standard dental implant surfaces. Each of these surfaces were disinfected and cleaned of all contaminants through UV-ozone treatment at 27˚C for 15 seconds.
- One set of surfaces were untreated (control), a second set was treated with EDTA (24%, 1 min, rinsed with saline), a third set was treated with glycine-airflow (1 min, rinsed with saline).
- Each surface was measured for wettability with a contact angle goniometer using a 36mg/ml albumin solution to model saliva.
- Two measurements were recorded for each surface, giving a total of four angle measurements each to determine their wettability.
- Statistical analysis was performed with ANOVA to compare the mean angle measurements between different sets of surfaces under each treatment approach.

***Fig. 2.* Contact Angle Goniometry Setup.** The setup for this method can be seen in this figure. A light source can be seen illuminating the sample where a camera can then capture the image of the sample on a flat surface. The angle between the surface and the sample can then be measured using computer software.



Results

- The average contact angle for the machined, sandblasted and SLA surfaces were as follows and can be seen in *Figures 4 and 5 as well as Table 1* below:

  Untreated surfaces: 51.25±2.12, 88.57±3.20, and 65.85±5.00, respectively

  Glycine-airflow-treated surfaces: 10.81±3.41, 20.04±4.31 and 9.40±0.19, respectively

  EDTA-treated surfaces: 18.58±1.20, 19.28±7.22 and 23.50±6.69, respectively

- The smallest contact angles for all three surfaces were obtained following glycine-airflow treatment and the largest contact angles were obtained from the untreated surfaces.
- Between the untreated groups, a difference in the contact angle was found between M/SLA or M/SA ($p<0.0001$) and SA/SLA ($p<0.0003$). Untreated surfaces had greater contact angle ($p<0.0001$) compared to the treated groups without significant differences between EDTA- and glycine-treated group ($p=0.15$).
- These results show that treating machined, sandblasted or SLA titanium surfaces with either EDTA or glycine airflow will increase the wettability of the titanium surface to an albumin solution, signifying a greater adhesive force between the two.
- Of the three surfaces, the machined surfaces had the lowest relative contact angles followed by the SLA surfaces and finally the sandblasted surfaces.

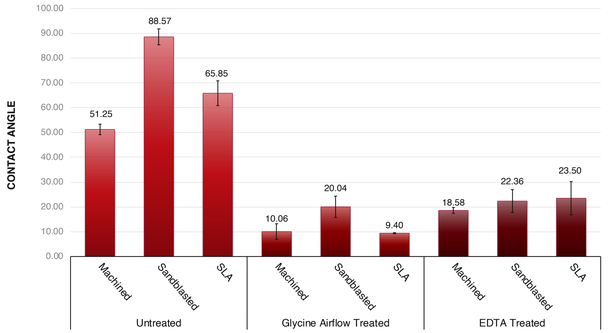


***Fig. 4.* Contact Angle Measurements for Each Surface.** Graphical representation of contact angle measurements with error bars representing standard deviation.

Table 1. Value of contact angle measurements for various titanium surfaces, including machined, sandblasted and SLA, with various treatment methods with standard deviations.

	Untreated	Glycine Airflow	EDTA
Machined	51.25 ± 2.12	10.06 ± 3.16	18.58 ± 1.20
Sandblasted	88.57 ± 3.20	20.04 ± 4.31	22.36 ± 4.60
SLA	65.85 ± 5.00	9.40 ± 0.19	23.50 ± 6.69

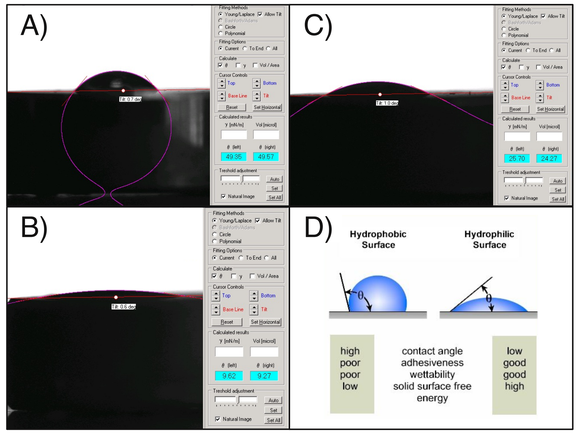


***Fig. 5.* Representation of contact angle measurements. A)** Untreated machined titanium surface. **B)** Glycine airflow treated SLA titanium surface. **C)** EDTA treated sandblasted titanium surface. **D)** Relationship between contact angle, adhesiveness, wettability and solid surface free energy.

Conclusion and Discussion

- The largest increase in wettability was found using glycine-airflow. This increased wettability demonstrates increased adhesive forces between albumin and treated titanium surfaces.
- These results could lead to increased adhesion between grafting materials and titanium surface, increasing the effectiveness of soft tissue grafting procedures.
- Treating the surface of implants prior to grafting procedures could help to increase the adhesion between the graft and the implant surface, leading to increased success of the procedures.
- While a decrease in contact angle was shown, the extent to which the adhesion between the surface and the albumin increased must still be measured. Future work should include SEM imaging of cleaned and treated surface, contact angle of albumin with the graft, contact angle of coated titanium surfaces, receding contact angle measurements and adhesive force measurements between the graft and the surfaces.

References

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