Heat Transfer of Impression Plasters to an Implant-Bone Interface

Joseph Nissan, DMD,* Martin Gross, BDS, LDS, MSc,† Zeev Ormianer, DMD,‡ Eitan Barnea, DMD,‡ and David Assif, DMD§

Purpose: *The purpose of this in vitro study was to measure heat generated at the implant-bone interface caused by exothermic setting reaction of 2 impression plasters.*

Materials and Methods: *The study consisted of 20 titanium-alloy abutment impressions connected to a titanium-alloy cylindrical implant embedded in an acrylic-resin mandible in a 37°C water bath. There were 2 types of impression plaster used, Snow-White (Kerr, Romulus, MI) and Xantano (Kulzer, Dormagen, Germany). Temperature changes were recorded via embedded thermocouples at the cervix and implant surface apex. Analysis of variance for repeated measures was used to compare 2 treatment groups.*

Results: *Temperature increased less at the implant apex (1.5°–2.1°C) than at the implant cervix (7.4°–10.5°C). Differences between the 2 impression plasters were statistically significant only at the implant cervical level (P < 0.05). A lower temperature increase was shown with the Snow-White compared with the Xantano. Although both plasters generated an exothermic reaction on setting (mean temperature change 22°C), the increase in the temperature rate of the Snow-White was slower than the Xantano.*

Conclusions: *Under the conditions of the present study, Snow-White impression plaster appears to be safer to use in implant prosthodontics compared with the Xantano because of its slower and lower exothermic reaction at the implant-bone interface. However, use of the material with the rapid setting time would require more care, such as limiting the volume of material used (e.g., by using a custom tray). (Implant Dent 2006;15:83–88)*

Key Words: ***impression plasters, dental implants, heat generation***

Impression plaster is commonly used intraorally to make impressions of an edentulous mouth or as a soldering index to join prosthetic components in conventional and implant prosthodontics (Fig. 1)[1-3] and has been an accurate impression technique for implant-supported prosthesis.[3] Impression plasters generate thermal energy on setting. The reaction is exothermic. When 1 g of calcium sulfate hemihydrate reacts with 1.5 g of water, 1 g of calcium sulfate dehydrate is formed, and 3900 calories of heat develop.[4-7] Overheating the tissues at the bone-implant interface can cause bone necrosis and compromise the bone's ability to survive as a well-differentiated tissue.[8-10]

Bone tissues become sensitive to heat at 47°C, as measured by here intravital microscopy. Rabbit tibiae heated to 50°C for 1 minute and 47°C for 5 minutes have shown a 30% to 40% bone resorption after 40 days, with bone tissue replaced by fat cells. When bone was heated to 47°C for 1 minute, fat cell injury and inconsistent bone injury were observed. Higher injury was reported after tissue was heated to 53°C for 1 minute, resulting in permanent vascular stasis and irreparable bone tissue necrosis.[8-10] Although there is no direct evidence that heat from the exothermic reaction of impression plaster causes a significant clinical problem, the temperature resulting from the exothermic setting reaction may cause adverse tissue reactions at the bone-implant interface. The purpose of this *in vitro* study was to measure the heat generated at the surface of a titanium-alloy implant caused by exothermic setting reaction of 2 impression plasters applied to an overlying abutment.

*Lecturer, Director Implant Prosthodontics, Department of Prosthetic Dentistry, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.
†Associate Professor, Director Graduate Prosthodontics, Department of Prosthetic Dentistry, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.
‡Instructor, Department of Prosthetic Dentistry, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.
§Associate Professor and Head, Department of Prosthetic Dentistry, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.

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Materials and Methods

A noncoated cylindrical integral titanium-alloy implant body, 4 mm in diameter and 10 mm in length (Sulzer Calcitek, Carlsbad, CA), was embedded in an acrylic-resin model of a human mandible. The mandible was immersed in a water bath (Hanau, Buffalo, NY) with a thermostatic temperature control mechanism maintaining the initial water temperature at 37°C. A titanium-alloy fixed abutment (Sulzer Calcitek), with a 2-mm gingival cuff length, was screwed into the implant body and isolated from the water level by a rubber dam tied with dental floss at the abutment cervix.[11]

Temperature Recording System

Thermocouple electrodes were attached to a flattened peripheral surface of the embedded implant at the cervical and apical aspects of the implant body. The connecting electrode wires were insulated with silicone. An additional electrode remained immersed in the water bath to measure the water temperature, and 1 was embedded into the impression plaster to measure temperature changes. Solid-state temperature sensors of 1 mA/Kelvin (Analogue Devices, Boston, MA), capable of measuring temperature changes of 0.1°C, were connected to a monitoring system (Atlas 8600 Physiolos, Tel Aviv, Israel) and to a personal computer, with 4 bands recording real-time temperature. Data were recorded at a rate of 1 sample per 0.55 second (Fig. 2).

Fig. 1. Although dimensionally accurate, impression of transfer copings using impression plaster can potentially generate damaging thermal energy at the connected implant neck.

TABLE 1. Mean Maximum Temperature Changes and 1-Way ANOVA for the 2 Impression Plasters

	Snow-White	Xantano
Mean maximum change in TA ± SD	1.85 ± 1.15	2.1 ± 0.4
F(*P*)	4.23*	
Mean maximum change in TC ± SD	7.44 ± 1.2	10.5 ± 2.47
F(*P*)	5.95†	
Mean maximum temperature change, IP ± SD	22.8 ± 1.9	22.08 ± 2.07
F(*P*)	0.01*	

* $P > 0.05$.

† $P < 0.05$.

IP indicates impression plaster; SD, standard deviation; TA, apical temperature; TC, cervical temperature.

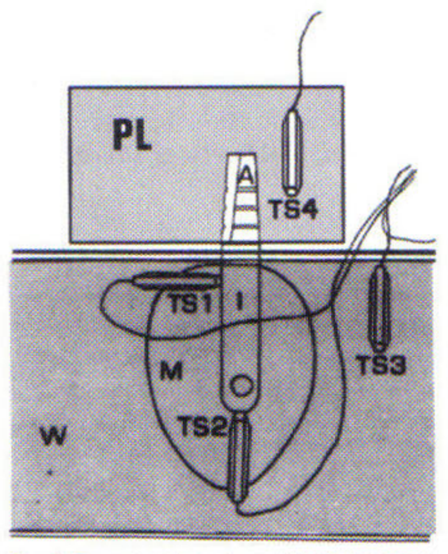

Fig. 2. Experimental set-up. A indicates abutment; I, implant; IP, impression plaster; M, mandible; TS1, cervical temperature sensor; TS2, apical temperature sensor; TS3, water temperature sensor; TS4, impression plaster temperature; W, water.

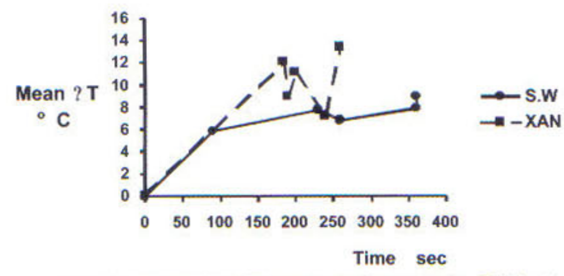

Fig. 3. Maximum temperature changes (ΔT) at the implant cervix. SW indicates Snow-White; XAN, Xantano.

Implant Impression Procedures

There were 2 types of commonly used impression plaster used to fabricate 20 impressions with custom acrylic resin trays. Group 1 contained 10 impressions of the master model made with Snow-White Plaster No. 2 (Kerr). Group 2 contained 10 impressions of the master model made with Xantano, Heraeus (Kulzer). Materials were mixed in standardized proportions according to the manufacturers' recommendations. The same operator performed all described procedures.

Statistical Analysis

One-way analysis of variance (ANOVA) for repeated measures was used, and the Fisher protected least significant difference post hoc test was used to detect and locate differences between test groups.

Results

Cervical Changes

Snow-White impression plaster produced a lower temperature increase (mean 7.44° ± 1.2°C) compared with the Xantano (mean 10.5° ± 2.47°C) at the implant cervix. One-way ANOVA showed statistically significant differences in implant cervical temperature between the 2 impression plasters ($P < 0.05$) (Table 1). The Snow-White showed a gradual increase in temperature between 90 and 360 seconds, with a range of temperature changes from 5.9°C to 9°C. The Xantano showed an initial increase in temperature of 7.2°C at 200 seconds, increasing rapidly to a maximum temperature change of 13.4°C at 250 seconds (Fig. 3).

Apical Changes

At the cervix, apical changes were 0.2% and reached a maximum temperature change increase of mean values of 1.5°–2.1°C. No statistically significant differences were found at the apex level between the 2 impression plasters (Table 1). The rate in seconds of temperature increase at the apex was similar to that of the implant cervix with, the Snow-White ranging from a temperature change of 0.4°–3.3°C and the Xantano ranging from 0.5°C to 2.5°C.

Maximum Temperature Changes

Both impression plasters generated exothermic reaction with no statistically significant differences between them (mean temperature change 22°C, $P > 0.05$) (Table 1). The rate in seconds of temperature increase in setting Xantano impression plaster was higher than that of the Snow-White.

Discussion

Impression plasters used in conventional and implant prosthodontics generate thermal energy on setting.[1-7] Excessive heat at the implant-bone interface may cause bone damage and compromise osseointegration. The volume of impression plaster contained in a stock impression applied to implant superstructures or impression posts can potentially pass significant levels of thermal energy to the implant-bone interface at the implant cervix. These can be sufficient in degree and duration to cause pathologic tissue changes.[8-10]

The findings of this study showed that although cervical temperature changes were seen for both materials, they were in the range of 2°-3°C. The differences between the 2 materials were statistically significant but may not be clinically relevant. Because changes in the rapidly setting material approached critical levels of 47°, its use should be performed with caution. This effect could be achieved by limiting the volume of material used with a custom tray or smaller stock trays. The findings of the present *in vitro* study indicate that temperature changes were less at the implant apex (increase of 1.5°–2.1°C) than at the implant cervix (increase of 7.4°–10.5°C). The differences between the 2 plasters were statistically significant only at the implant cervical level ($P < 0.05$) when the Snow-White impression plaster showed a lower temperature increase compared with the Xantano. Although both impression plasters generated an exothermic reaction on setting (mean temperature change 22°C), the increase in temperature rate of the Snow-White was slower than that of the Xantano.

A vital microscopic study has shown that 1 minute of heating bone at 47°C constituted a threshold level for bone survival.[8] The rate and magnitude of heating at the implant cervix were below this threshold level with the Snow-White because of its setting reaction, while the cervical temperature increase was within the range of 10°–13.8°C for 50 seconds because of the setting of the Xantano (Fig. 3). This is in the range estimated by Ericsson *et al*[8-10] to potentially compromise the adjacent bone.

Impression plaster is useful as an accurate impression material, particularly in the edentulous arch for implant-supported prostheses. Advantages of this material include rapid set, proven accuracy, rigidity without bending or distortion, ease of manipulation, less time-consuming than acrylic resin, and inexpensive.[1-7] A major disadvantage is that it can only be used in complete edentulous patients with no anatomic limitations (*e.g.*, bony undercuts). Under the conditions of the present study, Snow-White impression plaster was safer to use in implant-prosthodontics compared with the Xantano because of its slower and lower exothermic reaction at the implant-bone interface.

Conclusion

The 2 commonly used impression plasters tested, with a slower setting time, did not generate potentially damaging cervical implant temperature changes. The material with a more rapid setting time generated implant cervical temperature changes that approached the level of potentially compromising the supporting bone. Although being statistically significant, the difference in temperature between the 2 materials was in the range of 2°–3°C, which may not be significant clinically. However, use of the material with the rapid setting time would require more care, such as limiting the volume of material used (*e.g.*, by using a custom tray).

Disclosure

The authors claim to have no financial interest in any company or any of the products mentioned in this article.

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Reprint requests and correspondence to:
Joseph Nissan, DMD
Department of Prosthetic Dentistry
The Maurice and Gabriela Goldschleger
School of Dental Medicine
Tel Aviv University
Tel Aviv, Israel
Fax: (972) 3-6409250
E-mail: nissandr@post.tau.ac.il