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Temperature Rise During Intraoral Polymerization of Self-Cured Hard Denture Base Liners.

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Abstract- *The aim of this in-vivo study was to evaluate the temperature rise during polymerization of five chairside self-cured hard denture base reliners. For the same patient, 30 identical baseplates, exposing a space on their tissue surface to accommodate the lining material, were made of a light-cured denture base material. A hole was drilled in the center of this area to enable the thermocouple wire of the temperature measuring device to have direct access to the palatal surface of the baseplate. Six baseplates were used for each of the five lining materials tested. Temperature recordings were made every 15 seconds. Data were analyzed using single factor analysis of variance (ANOVA) and the Scheffe's post-hoc analysis for multiple comparisons. The mean maximum temperature values ranged from 40.2°C to 45.7°C being statistically different among the materials ($P<0.001$). The maximum peak temperature was 53°C and the lowest 39°C. Also the difference between the time each material reached the peak of temperature was statistically significant. ($P<0.0001$) A temperature range of 5.5°C was demonstrated among materials, with the highest polymerization temperatures recorded for Flexacryl Hard and the lowest for Rebase and GC Reline hard. Ufi-gel hard showed the fastest polymerization cycle and was the first to reach the maximum temperature. The available chairside hard liners must be chosen with care considering the thermal effect on the oral mucosa and the discomfort of patient.*

KEY WORDS: Liners, denture relining, chairside reliners, complete dentures, denture wearing.

INTRODUCTION

After the loss of all teeth there is a continuous and progressive reduction of the residual alveolar ridge[1-3]. Therefore, denture wearers usually present with retention problems or poor fit. Denture relining is usually performed to improve functional retention and stability of an ill-fitting denture. The direct reline by means of intraoral addition of so-called chairside liners on the tissue side of a denture is common in every day clinical practice[3,4]. The procedure is faster and does not result in any clinically significant dimensional change or warpage in the denture base [5]. However, many patients find the procedure uncomfortable[6]. This is due to chemical and thermal irritation of oral mucosa[7-9].

The newly introduced denture relining materials contain a variety of methacrylate monomers and polymers instead of methyl methacrylate (MMA) and poly (methyl methacrylate) (PMMA) in order to control the setting time and temperature, and minimize the mucosa irritation[10,11]. Despite the progress made in this field, temperature rising during relining, when exothermic energy is released, still remains a problem[6,12]. Bunch *et al*[12] reported temperature differences among self-cured hard chairside liners tested up to 10°C and stated that this difference may be clinically detectable.

According to American National Standard/American Dental Association specification number 17 for denture base temporary relining resin[13], the peak temperature should not exceed 75°C. However, even if oral mucosa has the capability to control temperature through the blood flow, temperatures above 57°C may cause burning sensation and burn[6,12]. For this reason some manufacturers recommend the removing of the relined denture from the mouth as the temperature rises. The effect of removing the incompletely cured resin from the mouth on the final fit of the denture is under question.

The aim of this study was to evaluate the temperature rise during intraoral polymerization of five commercially available self-cured hard chairside liners.

MATERIALS AND METHODS

The five self-cured denture lining resins used in this study are listed in Table 1.

Specimens' preparation

A maxillary impression was taken from an edentulous patient and the correspondent cast was poured (Vel-mix Stone, Kerr Mfg Co MI). A 30 x 30 x 2 mm soft polyethylene sheet was bonded to the tissue surface of the cast, across the palatal suture, with cyanoacrylate glue. 30 baseplates were made of a light-cured denture base material (Triad denture base material, Dentsply Int,). Each baseplate had a space of 30 x 30 x 2 mm on the tissue surface for the lining material. A hole was drilled at the centre of this area in order the thermocouple wire of the temperature measuring device to have access on the palatal surface of the baseplate (Photo 1).

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Table 1. Hard, direct self-cured denture lining resin

Trade name (code)	*Powder*	*Monomer*	*Manufacturer*
Flexacryl Hard (FH) *	PEMA	n-Butyl Methacrylate, dimethyl-p-toluidine	Lang Dental Mfg. co. Inc. Wheeling. Ill.
Ufigel Hard (UH) **	PEMA	Bis-GMA, UEDMA	VOCO GmbH, Cuxhaven, Germany
GC Reline Hard (RH) **	PEMA	Butoxyethyl- Methacrylate, benzyl-MA, 1,6-HDDMA	GC Corporation, Tokyo, Japan
Rebaron SC (RSC) ***	PMMA	Methyl-methacrylate, N,N-dimethyl-p-toluidine	GC Corporation, Tokyo, Japan
Tokuso Rebase Fast (TRF) ****	PEMA	MAOP, 1,6-HDDMA	Tokuyama Dental Corporation Tokyo, Japan

PEMA, poly(ethyl methacrylate); Bis-GMA, bisphenol-A-diglycidyl dimethacrylate; UEDMA, urethane ethylene dimethacrylate; HDDMA, hexanediol dimethacrylate; MAOP, β-methacryloyl oxyethyl propionate.

* http://www.langdental.com ** Mutluay and Ruyter[14] *** http://www.gceurope.com **** Seo *et al.*[15]

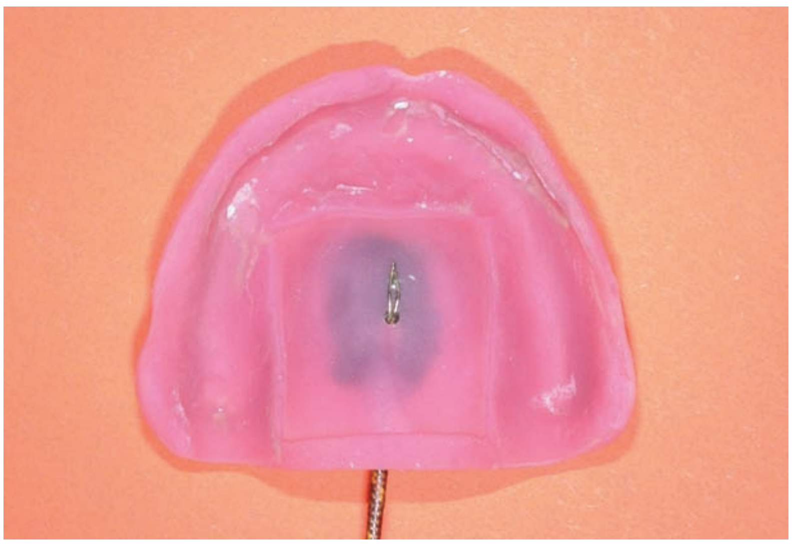


Photo 1. *Baseplate with relining area and the thermocouple wire.*

Temperature measuring device

The temperature measuring device, a type K thermocouple microprocessor thermometer (Antritherm, Anritsu Meter Co, Tokyo, Japan) was calibrated to 0°C using an ice point cell.

Experiment

The thermocouple wire was placed with its junction through the hole in the center of the space and was secured in this position with the aid of low viscosity modelling compound. Powder/liquid mixing ratios and mixing procedures followed the manufacturers' instructions. The relined materials was poured into the space of the baseplate which then was inserted into the mouth, aligned at its position and held with moderate pressure until the end of the experiment. Six baseplates were used for each of the five lining materials tested. (Photo 2)

Each day, at the same time of the day, one material was tested. The ambient temperature was controlled to 22±0.5 °C.

Temperature measurements

After the baseplate insertion into the mouth, in a couple of seconds the temperature rose up to 37°C which is the normal intraoral temperature for a human subject. This temperature was considered as the zero point for the experiment. Temperature recordings were made every 15 seconds. When the temperature was decreased back to 37°C, following the peak polymerization, this time considered to be the end of the experiment.

The maximum temperature value, the time at which the peak temperature value was achieved and the total time of the experiment for each material was recorded.

STATISTICAL ANALYSIS

Data were analyzed using single factor analysis of variance (ANOVA) and the Scheffe's post-hoc analysis for multiple comparisons was used. Levene's test was applied to test homogeneity of variance. All hypotheses were tested at

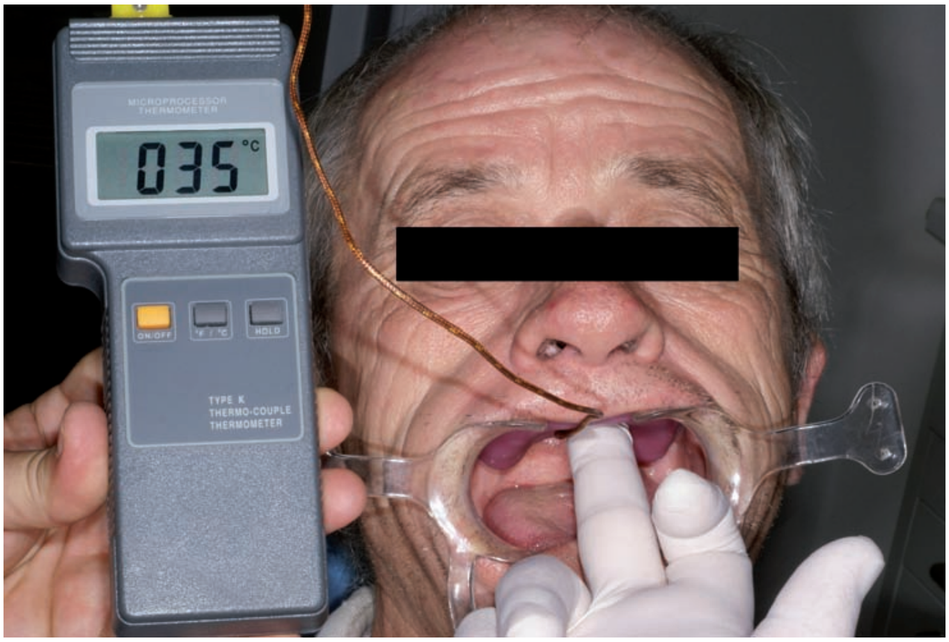


Photo 2. *Experimental procedure.*

the 95% level of confidence. The analyses were executed using SPSS for Windows statistical package (SPSS 6.1, SPSS Inc, Chicago Ill, USA).

RESULTS

The maximum temperature value ranged from 40.2±1.5°C for Tokuso rebase fast to 45.7±4°C for Flexacryl hard. The maximum peak temperature recorded at this study was 53°C for Flexacryl hard and the lowest was 39°C for Tokuso rebase fast and GC Reline hard. The maximum temperatures recorded were statistically different between the materials ($P<0.001$). (Fig. 1) Rebaron SC showed the most long-lasting polymerization cycle (467.5±11.3secs) compared to Ufi-gel hard which showed the fastest polymerization cycle (250±45.2secs). (Fig. 2) The differences between the materials, concerning the total time of the experiment, were statistically significant ($P<0.0001$). Moreover, the time each material reached the peak of temperature differed significantly. ($P<0.0001$) Specifically, Ufi-gel hard reached first the maximum temperature (155±18.2secs), whereas Rebaron SC needed 330±9.5 seconds to reach the maximum temperature. (Fig. 3)

DISCUSSION

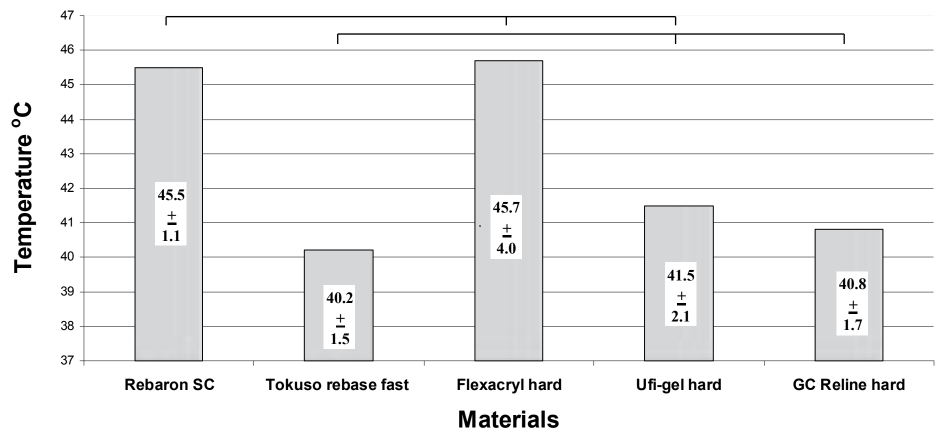
ADA Specification No. 17 for denture base temporary reline resins premises a stainless steel ring that provides a specimen depth of 2mm and an area of 39.3 cm^2. The resin is trapped into the specimen ring and two glass plates. The ambient temperature must be 23°C. Then the complex glass plates, stainless steel ring, resin and the thermocouple wire is inserted into a constant temperature oven at 37° C and in an atmosphere of 100% relative humidity[13]. This experimental design is far away from the real intraoral conditions. Other studies showed that peak temperature values measured according to ADA experimental guidelines are higher than intraoral measurements; moreover the temperature peaks occur much later[12,16]. This is very predictable since soft tissue adjacent to the polymerizing resin removes heat via conduction and blood flow and the intraoral temperature of 37°C accelerates the polymerization.

This study measured the temperature behavior of self-curing direct denture liners in conditions which are very similar with those occurred in every day clinical practice. The question that could be addressed at this point is "what is the temperature threshold that mucosa undergo permanent damage". This seems that is not clear in the available literature. The ideal material would be the one that holds the lower peak temperature value. Moreover, it is obvious that the faster polymerization cycle the relining resin exhibits the more comfortable for the patient is the whole procedure.

Concerning maximum temperatures, resins in this study could categorized into two groups which differ statistically significant; Flexacryl hard and Rebaron SC which showed higher values and Tokuso rebase fast and GC reline hard which exhibited lower temperatures. Ufi-gel hard showed an intermediate behavior (Fig 1) Attempting to relate materials' thermal characteristics during polymerization with chemical synthesis it can be seen that powder consisted of polyethyl methacrylate (PEMA) instead of polymethyl methacrylate (PMMA) except Rebaron SC. It seems that manufacturers changed the synthesis of the powder through recent years from methyl methacrylate to ethyl methacrylate polymers perhaps to control physical and mechanical properties including temperature rising. Bunch *et al*[12] measured mean values of 53.4°C for Perm (The Hygenic Corp, Akron, Ohio) and 51.9°C for Lang's self-curing rebase acrylic (Lang Dental Mfg. Co. Chicago) both materials being PMMA liners. At the same study PEMA liners KOOliner (Coe Laboratories, Inc. Chicago, Ill) and Flexacryl hard (Lang Dental Mfg. Co.Inc. Chicago Ill) exhibited lower temperatures, 41.6° C and 42.2° C respectively[12].

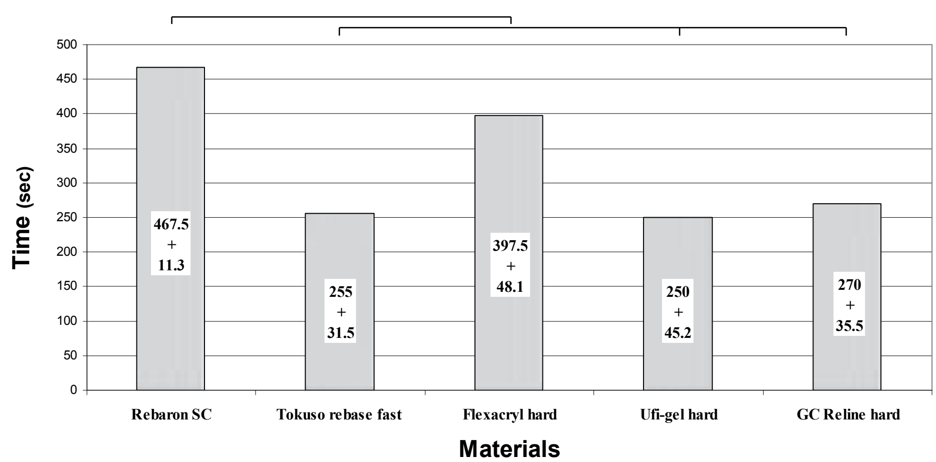
What is quite different among materials is the composition of liquid (Table 1). The cytotoxicity of methyl methacrylate and its vapour, as well as the tissue irritating monomers that gradually leach out of the polymerized material[7,8,17,18] forced manufacturers to exclude methacrylates from liquid. Table 1 shows that only Rebaron SC keept methyl methacrylate

Figure 1. *Maximum temperature (n=6)*



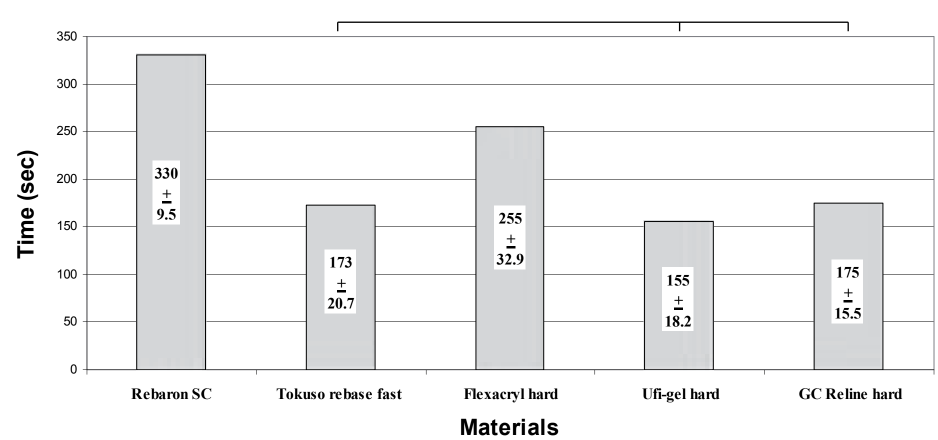
Denotes homogeneous subsets of the materials (P>0.05)

Figure 2. *End of the experiment (n=6)*



Denotes homogeneous subsets of the materials (P>0.05)

Figure 3. *Time of maximum temperature (n=6)*



Denotes homogeneous subsets of the materials (P>0.05) ingredient into its composition (powder and liquid) and at the same time showed high mean temperature values (45.5±1.1° C) (Fig 1). The same manufacturer (GC, Corporation, Tokyo, Japan) introduced a newer material GC Reline hard with no methyl methacrylate in its composition and excellent thermal behavior during polymerization (40.8±1.7°C) compared with previous material ($P<0.5$). It seems that thermal characteristics of the materials depend upon the composition and the combination of the powder and liquid in a way that only in-vivo measurements can reveal the real behavior of the material.

Tokuso rebase fast (40.2±1.5°C), GC reline hard (40.8±1.7°C) and Ufi-gel hard (41.5±2.1°C) showed an excellent performance keeping mean temperature values near the normal body temperature of 37°C. (Fig 1) In contrast Flexacryl hard (45.7°C) and Rebaron SC (45.5°C) showed higher values. Flexacryl hard exhibited the higher peak value of 53°C during the experiment. This finding confirms previous report[6] that temperature rising during polymerization can climb above 50°C. As it is mentioned earlier, the 57°C is considered as a threshold where patients feel uncomfortable and perhaps mucosa undergoes damage[6,12]. It is worthwhile noting that at the time the peak value of 53°C recorded for Flexacryl hard, the patient with the denture base into the mouth shifted on the chair commenting that he felt excess burning. For this reason some manufacturers recommend removing their products from the mouth as the temperature rises. Others[16], state that the relined dentures should be removed from the mouth within 30sec to 4min after the placement in it. It is under question if removing an incompletely cured relined denture from the mouth affects its final fit.

Concerning the total time each material completed polymerization, liners could categorized into two groups; Rebaron SC (467.5±11.3secs) and Flexacryl hard (397.5±48.1secs) which needed more time to complete polymerization compared to GC reline hard (270±35.5secs), Tokuso rebase fast (255±31.5secs) and Ufi-gel hard (250±45.2secs) with difference being statistically significant. (Fig 2) That means Ufi-gel hard needs about half of the time of Rebaron SC to complete polymerization.

Group; GC reline hard, Tokuso rebase fast and Ufi-gel hard, showed quite similar behavior to the time of peak temperature recorded. Generally all materials showed peak temperature at about two thirds of the total polymerization time (Fig. 3).

CONCLUSIONS

Under the conditions of this study we may conclude that

Tokuso rebase fast, GC reline hard and Ufi-gel hard showed an excellent performance keeping mean temperature values near the normal body temperature.

Flexacryl hard and Rebaron SC showed higher temperature values during the experiment.

Tokuso rebase fast, GC reline hard and Ufi-gel hard completed polymerization cycle faster than Rebaron SC and Flexacryl hard.

The available chairside hard liners must be chosen with care considering the thermal effect on the oral mucosa and the discomfort of patient. Dentists, in order to minimize thermal injuries of the oral mucosa must be aware of the heat development during self-cured hard liners polymerization.

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