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Effect of Arch Form and Water Sorption on the Palatal Base Adaptation of ProBase Hot Versus the Conventional Heat Cured Acrylic Resin

Research Article

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Abstract

Background: The greater the curvature of the tissue at the posterior palatal region, the greater the distortion of the denture base.
Purpose: This study was carried out to evaluate the effect of the arch form and water sorption on the posterior palatal base adaptation of ProBase Hot dentures compared to those processed by conventional heat cure acrylic resin.
Materials and Methods: Forty waxed denture bases were prepared for U-shaped and V-shaped palatine arch forms from both ProBase Hot and Acrostone materials. Waxed denture bases were flasked, packed and processed according to the manufacturer's instructions. Immediately after decasting, the dentures were repositioned on their corresponding casts to measure the amount of gap formed between denture base and cast at 5 points along the posterior border of denture base using a measurescope. Denture bases were stored in tap water for 4 weeks then the same test was repeated.
Results: Both palatine arch forms exhibited a significant amount of posterior palatine base discrepancy particularly at the center of the palate. The V-shaped arch form showed a greater amount of discrepancy than that with the U-shaped vault. ProBase Hot denture bases showed better palatal adaptation than that of the Acrostone denture bases. The posterior palatal base adaptation was significantly improved after immersion in water for 4 weeks at all points of measurements.
Conclusions: ProBase Hot denture bases showed better palatal adaptation than conventionally cured acrylic denture bases. All the tested groups demonstrated improved dimensional accuracy when stored in tap water for 4 weeks.

Keywords: Dental Polymers; Denture Adaptation; Discrepancy; Acrylic Resin; ProBase Hot.

Introduction

Because of its growing importance, acrylic resins have attracted a lot of study, both fundamental and applied (especially in the medical field). Although acrylic resins are almost exclusively used for the construction of denture bases, there have been some developments, such as the inclusion of higher functionality monomers so that the resins are cross-linked [1]. The major objective for construction of complete dentures is to obtain a denture base that conforms the supporting tissues to a high degree of accuracy. Intimate tissue contact and peripheral seal of the denture base comprise the most critical retentive factors. All available dental resins undergo shrinkage during processing. Poor denture adaptation was evident as a result of shrinkage of denture base [2].

The posterior palatal base shows the greatest amount of processing dimensional changes. The increased curvature of the tissue at the posterior palatal region (V-shaped palate), the decreased palatal adaptation [3]. Studies showed non-uniform distortion between the denture bases and their casts. The greater distortion was noted at the mid-palatal area of the posterior border of the denture bases. Discrepancies in at the mid-palatal area will negatively affect the retention of the denture [4].

Several studies indicated that the satisfactory processing temperature for the heat curing acrylic resin is between 71-77ºC to provide the best dimensional stability. There are two satisfactory processing procedures, (a) the first one is to cure the material in water bath at 74ºC for 8 hours or longer (long curing cycle); (b)

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the second is to cure the material in water bath at 74ºC for 1.5 hours and then at 100ºC for one hour (short curing cycle). The dimensional stability of the denture during processing and in service is important in the fit of the denture and the satisfaction of the patient [5].

Recent advances of poly-methyl methacrylate had been used for denture base construction. "ProBase Hot" was introduced as a new denture base material which is supposed to set a high standard of quality for the processing properties, accuracy of fit, and stability of shape than that of heat cured denture base materials. Gradual expansion of the acrylic dentures results after storage in water. It is believed that this expansion would partly compensate the processing shrinkage after several days [6]. Denture plastics of the same type may vary considerably in water sorption because of the presence of additives [7].

The adaptation accuracy of upper complete denture could be measured by measure microscope through measuring the gap space between the denture base and its cast [8-10]. The depth of the U-shaped palatal vault was between ¼ inch and ½ inch. The depth of the V-shaped palatal vault was exceeded ½ inch [9].

There are a little information available about the ProBase Hot denture base materials. The null hypothesis of this study was that ProBase Hot material is superior in palatal base adaptation when compared to the conventional denture base material. Therefore, the aim of this study was to evaluate the effect of arch form and water sorption on the posterior palatal base adaptation of maxillary ProBase Hot and Acrystone denture bases constructed on U-shaped and V-shaped arches.

Materials and Methods

Two completely edentulous patients were selected for conduction of this study. One patient had a moderately high U-shaped palatine vault, while the other patient had a high V-shaped palatine vault. The selected patients had maxillary alveolar ridges free of any obvious ridge undercuts and covered with firm, dense and healthy mucosa.

Irreversible hydrocolloid impression material [CavexCA37, Normal Set. Cavex Holland BV, P.O. BOX 852, 2003 RW Haarlem, The Netherlands] was used for making maxillary primary impressions. Immediately, the impressions were rinsed and poured into plaster to produce primary casts. Special trays were fabricated using auto-polymerized acrylic resin [Acrostone cold cure denture base material, Acrostone dental factory, Industrial zone, El-Salam city, Egypt]. These trays were spaced and border molded using green stick compound [Green sticks impression compound. Kerr Italian S.r.l., via Passanti332, I-84018 Scafati, Salerno, Italia].

Zinc oxide eugenol impression material [CavexCA37, impression paste. Cavex Holland BV, P.O. BOX 852, 2003 RW Haarlem, The Netherlands] was used for making secondary impressions under slight pressure to the mucosa. These impressions were rinsed, boxed and poured in extra-hard dental stone [Kopo-Rock CKR-35, super dental rock. Kopo-Dental, ISI-KUANG PANG]. Two sets of master casts were produced, one for U-shaped and the second for V-shaped arch forms.

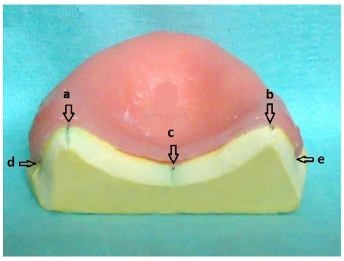
Beveling of the master casts were made along the posterior borders to allow accurate measurements of the posterior palatal space. Five scratches were made on the posterior wall of the maxillary master cast as reference marks using a sharp scalpel. These points for measurements of the posterior palatal spacing were; point "a" at the right ridge crest; point "b" at the left ridge crest; point "c" at the midline of the palate; point "d" at the right buccal area; and point "e" at the left buccal area (Figure 1).

Reversible hydrocolloid [Technojel reversible duplicating material. Protechno, E-17469 Vilamalla (Girona), Spain] was used for duplication of the master casts to produce twenty stone casts. Each master cast was first soaked in water for 15 minutes and then fixed to the base of aluminum duplicating flask by sticky wax. Sticky wax was used for fixation of the casts to base of the flask. The molten reversible hydrocolloid was poured from an opening on the top cover of the flask. After complete gelation of the reversible hydrocolloid duplicating material, the base of the flask was opened to release the maxillary cast. The reversible hydrocolloid mold cavity was poured in dental stone. Forty stone casts were produced; twenty casts for U-shaped maxillary arch and twenty casts for V-shaped maxillary arch.

To produce standardized maxillary denture bases, the waxed denture base was duplicated using the putty form of silicone elastomeric impression material [Alphasil Perfect. Muller-Omicron GmbH & Co. KG, D-51789 Linder, Germany]. The impression was done for the maxillary denture base together with its master cast, using a large stock tray contoured with base-plate wax. The excess material was trimmed to be flushed with the borders of the base of the cast. After setting of the elastomeric impression material, the waxed denture base together with its master cast was removed. Two escaping holes were prepared at the rear wall of the rubber base impression mold.

One of the duplicated casts was seated in its position in the elastomeric impression mold. The cast and the mold were tightened together using a rubber band. Molten base-plate wax [CavexSetUp Regular Modelling wax. Cavex Holland BV, P.O. Box 832, 2003

Figure 1. Shows the measuring reference points.



RW Haarlem, The Netherlands] was poured in the elastomeric impression mold from one hole previously prepared at the rear of the impression mold. Air and excess molten wax were escaped from the other hole. After wax was cooled, the cast and wax denture base were removed from the impression mold. The previous procedure was repeated for all the duplicated casts. Twenty standardized denture bases were prepared for each arch form.

Flasking of all waxed denture bases were done using stone-plaster mix and pressed under the hydraulic press. The waxed denture bases were washed out of wax. Ten denture bases were processed from conventional heat cured acrylic resin [Acrostone Heat cure denture base material. Acrostone Dental factories, Industrial zone, EL-Salam city, Egypt.], and ten were processed from ProBase Hot denture base [ProBase Hot® Heat cure denture base material, Ivoclar Vivadent AG. Bendererstrasse 2. 9494 schaan/ Liechtenstein]; according to the manufacturer's directions of each material. The conventional heat cured denture bases were cured in water bath at 74°C for 1.5 hours and then for 100°C for 1 hour. ProbaseHot denture bases were placed in cold water bath and heated up to 100°C and let boil for 45 minutes. After curing, the flasks were left to cool slowly to room temperature before deflasking. Four groups of denture bases were produced as follow:

Group A. Ten denture bases were cured from the conventional heat-curing acrylic denture base material fabricated on casts with normal U-shaped palatal arch form.
Group B. Ten denture bases were cured from the conventional heat-curing acrylic denture base material fabricated on casts with normal V-shaped palatal arch form.
Group C. Ten denture bases were cured ProBase Hot denture base material fabricated on casts with normal U-shaped palatal arch form.
Group B. Ten denture bases were cured from ProBase Hot denture base material fabricated on casts with normal V-shaped palatal arch form.

The posterior palatal spacing was measured using a two dimensional measurescope [Nikon, japan] with a measuring accuracy of 0.001 mm at the five reference points. The same measurements were done after water storage of the denture bases for 4 weeks. The measurement was repeated 3 times for each reference point.

Statistical Analysis

The recorded data were statistically analyzed by using ANOVA test at 5% level of significant. If the F-test showed a significant difference, Least Significant Difference (LSD) test was performed to compare the significant differences between the groups.

Results

Mean values of denture base distortion for maxillary ProBase Hot and Acrostone at points (a, b), measured immediately after decasting and after 4 weeks of water immersion are presented in Tables 1 and 4. There were no significant differences between all denture bases at these points of measurements immediately after decasting or after 4 weeks of water immersion.

Mean values of denture base distortion for maxillary ProBase Hot and Acrostone at point (c), measured immediately after decasting are presented in Table 2. There were significant differences between ProBase Hot and Acrostone denture bases at point (c) in both arch forms. There was no significant difference between the arch forms for ProBase Hot. There was a significant difference between the arch forms for Acrostone.

Mean values of denture base distortion for maxillary ProBase Hot and Acrostone at point (c), measured after immersion in tap water for 4 weeks are presented in Table 5. There were significant differences between ProBase Hot and Acrostone denture bases at point (c) in both arch forms except for V-shaped ProBase Hot and U-shaped Acrostone. Also, there was a significant difference between arch forms for each material separately.

Mean values of denture base distortion for maxillary ProBase Hot and Acrostone at points (d, e), measured immediately after decasting and after 4 weeks of water immersion are presented in Tables 3 and 6. There were no significant differences between all denture bases at points (d, e) immediately after decasting or after 4 weeks of water immersion.

Mean distortion values for maxillary Acrostone denture bases measured at all points of measurements immediately after decasting and after 4 weeks of water immersion are presented in Table 7. The posterior palatal base discrepancy was significantly decreased after immersion in water for 4 weeks at all points of measurements.

Mean value of discrepancy for ProBase Hot denture bases at all points of measurements before and after immersion in tap water for 4 weeks are presented in Table 8. The posterior palatal base discrepancy was significantly decreased after immersion in water for 4 weeks at all points of measurements.

Discussion

All available resins used in dentistry undergo shrinkage during processing [11]. One decided advantage of poly (methyl methacrylate) as a denture base material is the relative ease with which

Table 1. Mean value of discrepancy in mm for maxillary ProBase Hot and Acrostone denture bases for U - and V - shaped arch forms at points (a, b), measured immediately after decasting.

	ProBase Hot Mean ± SD	Acrostone Mean ± SD	LSD	P-value
U-shaped vault	0.079 ± 0.021	0.111 ± 0.040	0.054	P ≥ 0.05
V-shaped vault	0.102 ± 0.065	0.120 ± 0.051		

P ≥ 0.05 no significant difference.

Table 2. Mean value of discrepancy in mm for maxillary ProBase Hot and Acrostone denture bases for U - and V - shaped arch forms at point (c), measured immediately after decasting.

	ProBase Hot Mean ± SD	Acrostone Mean ± SD	LSD	P-value
U-shaped vault	0.414^{C} ± 0.085	0.594^{B} ± 0.111	0.104	P ≤ 0.05
V-shaped vault	$0.508^{B,C}$ ± 0.072	0.698^{A} ± 0.065		

P ≤ 0.05 significant difference.

Means with the same superscripted letters are not significantly different.

Table 3. Mean value of discrepancy in mm for maxillary ProBase Hot and Acrostone denture bases for U - and V - shaped arch forms at points (d, e), measured immediately after decasting.

	ProBase Hot Mean ± SD	Acrostone Mean ± SD	LSD	P-value
U-shaped vault	0.173 ± 0.06	0.146 ± 0.02	0.047	P ≥ 0.05
V-shaped vault	0.121 ± 0.010	0.156 ±0.034		

P ≥ 0.05 no significant difference

Table 4. Mean value of discrepancy in mm for maxillary ProBase Hot and Acrostone denture bases for U - and V - shaped arch forms at points (a, b), measured after immersion in tap water for 4 weeks.

	ProBase Hot Mean ± SD	Acrostone Mean ± SD	LSD	P-value
U-shaped vault	0.053 ± 0.014	0.069 ± 0.026	0.049	P ≥ 0.05
V-shaped vault	0.082 ± 0.037	0.102 ± 0.042		

P ≥ 0.05 no significant difference.

Table 5. Mean value of discrepancy in mm for maxillary ProBase Hot and Acrostone denture bases for U - and V - shaped arch forms at point (c), measured after immersion in tap water for 4 weeks.

	ProBase Hot Mean ± SD	Acrostone Mean ± SD	LSD	P-value
U-shaped vault	0.340^{C} ± 0.075	0.526^{B} ± 0.084	0.103	P ≤ 0.05
V-shaped vault	0.494^{B} ± 0.062	0.675^{A} ± 0.055		

P ≤ 0.05 significant difference.

Means with the same superscripted letters are not significantly different.

Table 6. Mean value of discrepancy in mm for maxillary ProBase Hot and Acrostone denture bases for U - and V - shaped arch forms at points (d, e), measured after immersion in tap water for 4 weeks.

	ProBase Hot Mean ± SD	Acrostone Mean ± SD	LSD	P-value
U-shaped vault	0.119 ± 0.052	0.160 ± 0.037	0.050	P ≥ 0.05
V-shaped vault	0.120 ± 0.009	0.130 ± 0.062		

P ≥ 0.05 significant difference.

it may be processed. Heat activated materials are used in the fabrication of nearly all denture bases. It was evident that the commercial products highly influenced the dimensional stability of the acrylic resin bases [12]. The dimensional changes of the denture base result from both polymerization shrinkage and stresses released during flask cooling [12, 13]. The magnitude of the acrylic resin dimensional changes, however, may be influenced by several factors, such as polymerization techniques, where the internal stresses are produced by different coefficients of thermal expansion of gypsum and acrylic resin [14], and the base thickness may vary at different sites inside the flask [14, 15] altering the denture base adaptation and stability [16].

Master casts were modified before duplication to transfer the same modifications to all the tested casts. The rear of each master cast was beveled to allow clear vision of the points of measurements during accuracy tests. Deep scratches were prepared on the master casts just below each point of measurement to be used later as a reference point. Duplication of each master cast was done using Agar-Agar which reproduce accurate duplicates, transferring all the details to the test casts. Standardization of the maxillary denture bases was essential to eliminate the effect of different

Table 7. Mean value of discrepancy in mm for Acrostone denture base at all points of measurements before and after immersion in tap water for 4 weeks.

Points	Time	Mean ± SD	P-value
(a + b)	After decasting After water immersion	0.115 ± 0.044 0.085 ± 0.037	P ≤ 0.01
(d + e)	After decasting After water immersion	0.150 ± 0.028 0.135 ± 0.021	P ≤ 0.05
(c)	After decasting After water immersion	0.623 ± 0.095 0.577 ± 0.094	P ≤ 0.05

P ≤ 0.01 & 0.05 significant differences.

Table 8. Mean value of discrepancy in mm for ProBase Hot denture base at all points of measurements before and after immersion in tap water for 4 weeks.

Points	Time	Mean ± SD	P-value
(a + b)	After decasting After water immersion	0.091 ± 0.048 0.068 ± 0.031	P ≤ 0.05
(d + e)	After decasting After water immersion	0.147 ± 0.046 0.115 ± 0.036	P ≤ 0.001
(c)	After decasting After water immersion	0.461 ± 0.090 0.417 ± 0.103	P ≤ 0.01

P ≤ 0.01 & 0.05 significant differences.

denture base thickness on the pattern of denture distortion [13].

Besides the factors inherent to the physical properties of acrylic resin, technical procedures and the anatomical conditions of the patient's mouth have been demonstrated previously in the literature [12]. Consequently, the combination of polymerization shrinkage and strain release decreases the adaptation level of denture base to the supporting tissue, influencing the denture base stability [17].

It would be desirable to verify the effect of commercial heat cured acrylic resins on denture base adaptation and clinical fitness. Processing shrinkage of maxillary acrylic denture bases is particularly noticeable in the posterior palatal border region, where the retentive seal and stability of the prostheses can become compromised [18, 19]. Although the dental position modified by linear changes may be easily corrected by occlusal adjustment, the palatal posterior region, considered to be a critical area in relation to base retention, will be hardly corrected after processing. The processing shrinkage which occurs during polymerization is not uniform [15] and being more evident in the posterior palatal region whilst the dimensional distortion occurs during cooling or after the base is separated from the cast [20].

Gradual expansion of the acrylic dentures results after storage in water. It is thought that this expansion would partly compensate the processing shrinkage after period of time [21]. Denture plastics of the same type may vary considerably in water sorption because of the presence of additives [5]. The denture bases were stored in water at room temperature for 4 weeks; as the major portion of the expansion in water takes place during the first month, and the changes are insignificant after 2 months [7]. Although all tested denture bases revealed expansion with no significant difference between groups, ProBase Hot showed the best results towards adaptation. This could be explained by the fact that denture plastics of the same type may vary considerably in water sorption because of the presence of additives [5].

It would be desirable to verify the effect of commercial heat cured acrylic resins on denture base adaptation and clinical fitness. This study was done to verify the dimensional changes of denture bases processed with ProBase Hot which is a commercial heat cured acrylic resin supposed to give high standards of accuracy and fitness [22, 23] and to compare the results with those of conventionally used heat cured acrylic resin (Acrostone) for U-maxillary palatal vault shape. To verify the aim of this study, the selected patients to participate had maxillary edentulous arches free from any obvious undercuts to facilitate decasting of the denture after processing and avoid denture distortion during its removal. Severe undercuts increase denture retention which may affect the dislodging force, and the relief of exaggerated tissue undercuts will deteriorate denture peripheral seal and decrease retention [24].

This study was restricted to the maxillary edentulous arch because locations of the seal areas responsible for retention are constant and don't move during the ordinary functions of the mouth, unlike the mandibular arch [25, 26]. The denture bases were tested for accuracy immediately after decasting since the distortion upon removal of the denture from the cast was greater than any other subsequent changes, due to strain relaxation [7]. Points of measurement were decided to be along the posterior border of the denture base; since studies showed that accuracy was better from the anterior to the middle of the palate and become worse toward the posterior of the denture [7, 12].

ProBase Hot denture bases showed a highly significant decrease in gap formation compared to Acrostone denture bases particularly at point (c) representing mid palatal point along the posterior borders of denture bases. ProBase Hot denture bases also showed the least mean values for gap formation regarding the other points of measurements, when measured after decasting. ProBase Hot material showed the least distortion when compared to other commercial products [22]. This may be attributed to the difference in cross-linking agent between different commercial products [27], as ProBase Hot rely on high levels of crosslink resin and heat activated initiators to maximize the physical properties of the processed materials [28]. For all the tested denture bases, the greatest amount of discrepancy was found in the center of the palate, and then decreased toward the crest of ridge. The possible explanation to this phenomenon may be due to the shrinkage of the resin toward the areas of the greatest bulk, which is the ridge portions of the denture base, such shrinkage causes a tensile stresses to occur in the thinner palatal region, when these stresses are relieved, the resin pulled away from the palate [29].

Also this study revealed that the distortion at buccal areas was greater than that at the ridge crests. The magnitude of the acrylic resin dimensional changes may be influenced by the base thickness which may vary at different sites between marginal and central zones inside the flask. Also, a region which is flatter, less restrictive and permits strain release, could produce more evident distortion [15]. This may explain the greater magnitude of distortion at buccal areas.

Patients exhibiting highly tapered, steep (V-shaped) palatal vaults present a special problem. Retention by adhesion is diminished because the palate, having sloping sides, offers only a small area which is horizontal to a vertical displacing force [30]. The dimensional changes in complete dentures during processing, demonstrated that the dimensional changes in frontal and vertical planes were maximum in V-shaped palatal vault dentures. In this study, U- shaped denture bases showed better adaptation than V-shaped denture bases [21]. This is attributed to the palatal geometry which affects the way stresses are released and thus affect distortion pattern [19]. ProBase Hot showed the best adaptation with V-shaped palatine vaults concerning this investigation, which makes it a better choice when dealing with such cases.

The measurements done after water immersion for 4 weeks revealed significant difference for all the tested groups, leading to better adaptation. This means that water sorption was evident for both ProBase Hot and Acrostone causing expansion of the denture bases. This may be explained by the fact that poly (methylmethacrylate) absorbs water between the macromolecules according to the law of diffusion. The macromolecules are forced apart by the diffusion of water, resulting in stress relieving with consequent relaxation and denture distortion [7]. Although all tested denture bases revealed expansion with no significant difference between groups, ProBase Hot showed the best results towards adaptation. This could be explained by the fact that denture plastics of the same type may vary considerably in water sorption because of the presence of additives [5].

Conclusions

From the results of this study it was concluded that:

1. ProBase Hot denture bases showed better dimensional accuracy than conventionally used acrylic denture bases.
2. ProBase Hot is a better choice for constructing denture bases for V-shaped palatine vaults to compensate for the increased distortion due to palatal shape.
3. All the tested groups demonstrated improved dimensional accuracy when stored in tap water for 4 weeks.

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