

CLINICAL RESEARCH

## Effects of denture adhesive on the retention of milled and heat-activated maxillary denture bases: A clinical study



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In 2050, it is expected that approximately 8.6 million people or 2.6% of the US population will require complete dentures (CDs).<sup>1</sup> The retention of CDs, a key factor for successful treatment, is influenced by physical, physiologic, psychologic, mechanical, and surgical factors.<sup>2</sup> Poor retention leads to the use of denture adhesives<sup>3</sup> to improve the retention of the prosthesis (particularly in patients with severely resorbed ridges), increase the occlusal forces, and reduce the amount of denture movement.<sup>4,5</sup> Denture adhesives also promote a faster and more natural rate of mastication,<sup>6</sup> reduce the accumulation of food particles under the denture, and can be used to stabilize denture bases during maxillomandibular jaw relation recording.<sup>7</sup> Denture adhesives are safe and effective.<sup>8</sup> However, their disadvantages include papillary hyperplasia<sup>9</sup> and an increased occlusal vertical dimension.<sup>10</sup>

Denture adhesives are composed of short- and long-acting synthetic polymers that hydrate and increase in

### ABSTRACT

**Statement of problem.** Clinical studies have identified advantages of digital complete denture technology including patient satisfaction, improved mastication, increased retention, and technique efficiency. However, studies that focus on the effect of denture adhesive on the retention of milled and heat-activated denture bases are lacking.

**Purpose.** The purpose of this clinical study was to evaluate the effectiveness of denture adhesive on the retention of milled and heat-activated denture bases.

**Material and methods.** Twenty participants with complete maxillary edentulism were selected for this study (11 men and 9 women). Definitive impressions were obtained and scanned (iSeries impression scanner; Dental Wings). Digital data were sent to Global Dental Science for the fabrication of computer-aided design and computer-aided manufacturing (CAD-CAM) milled denture bases (MB condition). The physical impressions were poured in stone to produce casts for the fabrication of heat-activated acrylic resin denture bases (HB condition). A portable clinical motorized test stand and advance digital force gauge were modified to measure the amount of denture base retention in newtons. The denture bases were seated over the edentulous maxillary ridge and pulled 3 times vertically at 10-minute intervals without denture adhesive (MB and HB control conditions) and with denture adhesive (MBA and HBA test conditions). For statistical analysis, a repeated-measures ANOVA was performed ( $\alpha=.05$ ).

**Results.** The control MB condition had significantly higher retention values compared with all other conditions ( $P<.001$ ). However, the use of adhesive significantly decreased the retention of the milled bases. No significant differences were found with or without the use of denture adhesive among heat-activated denture bases ( $P>.05$ ).

**Conclusions.** Significantly higher retention values were recorded with milled denture bases than heat-activated resin bases without the use of denture adhesive. However, denture adhesive did negatively affect the retention of milled complete dentures. (J Prosthet Dent 2018;120:361-6)

volume to fill spaces between the intaglio surface of the denture and mucosal tissues. In addition, the increased viscosity of the hydrated adhesive helps to optimize interfacial forces that aid in denture retention. The long-acting polymers improve cohesive forces within the

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## Clinical Implications

Milled complete denture bases provide better retention without denture adhesive than when adhesive is used. Therefore, patients should be cautioned not to use denture adhesive with milled complete dentures.

adhesive through molecular cross-linking, which increases the strength of the adhesive film and extends resistance to wash out from under the denture.<sup>11</sup>

The use of denture adhesive has been objectively investigated in multiple clinical studies<sup>12-19</sup> and has proved effective for patients with ill-fitting dentures.<sup>12</sup> Incisal force significantly improved for patients using denture adhesive<sup>13</sup> for old and newly made dentures.<sup>14,15,20</sup> Moreover, when denture adhesive was used, resistance dislodgement forces improved for new dentures worn for 90 days compared with new dentures worn for 45 days and those worn immediately after placement.<sup>19</sup>

The digital design and fabrication of removable prostheses is a recent innovation.<sup>21,22</sup> Milling denture bases from prepolymerized acrylic resin blocks results in less polymerization shrinkage compared with the more commonly used conventional denture base process.<sup>21</sup> Compared with the conventional method, milling produces more accurate denture bases that are highly reproducible.<sup>23</sup> Baba et al<sup>24</sup> stated that the benefits of digital removable CD over conventionally fabricated CD include reducing the number of clinical appointments, the overall treatment time, and the cost. Furthermore, an additional or replacement denture can be easily fabricated because all the needed information is stored digitally.<sup>21,24-26</sup>

Recently, the retention of maxillary milled and heat-activated denture bases was compared in a clinical study,<sup>27</sup> and the authors reported better retention with milled bases. However, the authors are unaware of previous studies that have evaluated denture retention when denture adhesive was used. Therefore, the purpose of this study was to clinically evaluate the effect of denture adhesive on the retention of digitally milled and heat-activated denture bases. The null hypothesis was that no difference in retention would be found between digitally milled denture bases and heat-activated denture bases when denture adhesive is used.

## MATERIAL AND METHODS

This study was conducted after receipt of institutional review board approval (approval 5140396). A total of 20 participants with complete maxillary edentulism were selected for the study (Table 1). The inclusion criteria were complete edentulism for at least 1 year and being at

**Table 1.** Participant demographics

Demographic	Value
Ethnicity	
White	13 (65%)
Hispanic	3 (15%)
African American	2 (10%)
Hawaiian	2 (10%)
Sex	
Male	11 (55%)
Female	9 (45%)
Age (y), mean $\pm$ SD	68.20 $\pm$ 7.27

least 18 years old. All participants provided signed informed consent. The exclusion criteria included a history of receipt of medication that would alter the quantity and quality of saliva, the presence of severe ridge undercuts, the presence of palatal tori that required surgical correction, and the presence of ridge or soft tissue pathology.

At the first visit, the maxillary arch was classified according to the Prosthodontic Diagnostic Index classification system.<sup>28</sup> Also, the House palatal throat form, arch size, and arch form were recorded (Table 2). A preliminary impression was made using an irreversible hydrocolloid impression material (Jeltrate; Dentsply Sirona). The impression was poured according to the manufacturer's instructions with Type III dental stone (Microstone; Whip Mix Corp). A custom tray was fabricated from light-polymerizing resin (Triad Tru Tray Sheet; Dentsply Sirona). The tray was trimmed 2.0 mm away from the depth of the vestibular sulcus (facial and buccal) to permit border molding.

Participants were told not to wear their existing maxillary CD for 24 hours before the second visit. The custom tray was inspected intraorally and adjusted as needed. Heavy-body polyvinyl siloxane impression material (Aquasil; Dentsply Sirona) was used to border mold the custom tray. The definitive impression was completed with light-body polyvinyl siloxane impression material (Aquasil; Dentsply Sirona). The area of the posterior palatal seal (PPS) was marked intraorally using an intraoral marking stick (Dr Thompson's Marking Sticks; Shatkin F.I.R.S.T. LLC). The PPS area was recorded on the maxillary impression using wax (Korecta Extra Soft; Patterson Dental Supply Inc). Border molding, definitive impression, and PPS outline procedures were inspected and completed by one of the authors (H.R.). The definitive impressions were scanned with a laboratory scanner (iSeries; Dental Wings) within 24 hours to record the impression. Standard tessellation language (STL) files were sent digitally to Global Dental Science for fabrication of denture bases (AvaDent) for the milled base (MB) condition. For fabrication of the heat-activated base (HB) condition, the definitive impressions were

**Table 2.** Clinical data of all participants

Characteristic	n (%)
Arch form	
Round	8 (40)
Square	8 (40)
Tapered	4 (20)
Maxillary ridge morphology type	
A (resists vertical and horizontal, hamular notch, no tori)	9 (45)
B (no buccal vestibule, poor hamular notch, no tori)	7 (35)
C (no anterior vestibule, minimal support, mobile anterior ridge)	4 (20)
House palatal throat form	
I	7 (35)
II	7 (35)
III	6 (30)

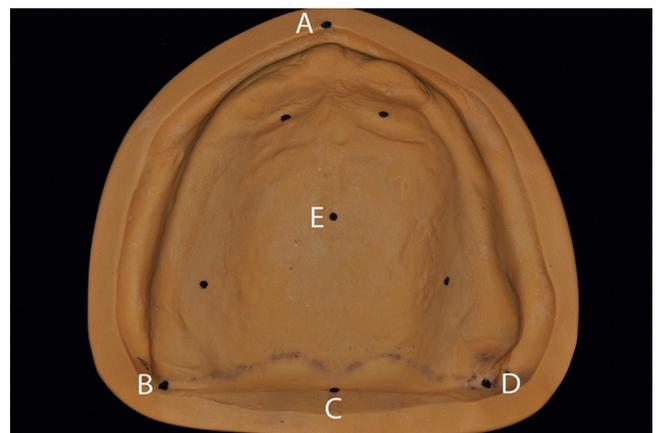
poured with Type III dental stone (Microstone; Whip Mix Corp), and heat-activated denture base resin (Lucitone 199; Dentsply Sirona) was used. A long polymerization cycle was selected for the heat-activated denture bases, which calls for 9 hours in a water bath at  $73^{\circ}\text{C} \pm 1^{\circ}\text{C}$  followed by 30 minutes in boiling water, according to the manufacturer's recommendations. A stainless steel hook attachment was fixed in the center of the denture base using chemically activated acrylic resin (Lucitone 199 Repair Material; Dentsply Sirona) that was left to polymerize for 10 minutes at  $43^{\circ}\text{C}$ .<sup>27</sup> MBs and HBs were kept hydrated in water after fabrication. Before the final visit, the participants were informed that, for testing purposes, they were not to wear their CD in the maxillary arch for 24 hours before the appointment.

The testing device used in this study has been described in a study that compared the retention of milled and heat-activated denture bases in the maxilla.<sup>27</sup> It consisted of a motorized test stand (ESM301L; Mark-10 Corp) set at a crosshead speed of 50.8 mm/min to systematize the pulling rate for the participants; an advanced digital force gauge (ADFG) (Series 5; Mark-10 Corp) with a grip attachment used to provide the force required to displace the denture base from the participant's maxillary ridge with the participant in an upright position; a facebow (Panadent Corp) to standardize the head position during testing procedures; and an autoclavable force transmission device made of a hollow aluminum rod with a small pulley at each end (Fig. 1). A disposable nylon thread joined the hook on the cameo surface of the denture base and the ADFG through the hollow autoclavable force transmission device.

At the final visit, the milled and heat-activated denture bases of the control conditions were individually seated intraorally. Corrections were made as needed using pressure indicator paste (Henry Schein Inc) to detect premature soft tissue contact areas. Then landmarks were marked on the maxillary casts (Fig. 2). The center of each denture base was located on the maxillary definitive cast by marking the mucosa overlying the



**Figure 1.** Testing apparatus. Digital advanced force gauge (A). Motorized test stand Mark 10 extended-length ESM301L (B). Wood stand (C). Force transmission device (D). Grip attachment (E). Panadent facebow (F).



**Figure 2.** Maxillary cast landmarks.

pterygomaxillary fissures (points B and D) and the center of the labial frenum (point A). Half the distance between points B and D was marked as the midposterior border of the denture base (point C). Half the distance between point A and C was marked as the center of the denture base (point E). Point E was visible through the definitive cast and could be marked on the denture base. To standardize the location of the denture adhesive placement, bilateral imaginary straight lines between points A to D and A to B were measured. Each imaginary line was divided by 4. Then 2 points equidistant between points A to D and A to B were selected.

For the test conditions with denture adhesive, conditions MBA and HBA were studied (Table 3). Four spots of 0.2 mL of denture adhesive (Fixodent; Procter & Gamble Co) were applied to the intaglio surface of the denture base (Fig. 3A). A sterile plastic syringe was used to standardize the amount of paste<sup>12</sup> (Fig. 3B). The bases from the MBA and HBA conditions were immersed in water to allow for denture-adhesive wettability, and then the excess water was shaken off.

**Table 3.** Group descriptions

Group	Methods of Fabrication	Adhesive
MB	Digitally milled base	No
HB	Heat-activated base	No
MBA	Digitally milled base	Yes
HBA	Heat-activated base	Yes

The MB and HB control conditions were seated interchangeably over the edentulous maxillary arch for 5 minutes, allowing for tissue adaptation before the testing procedure. Each denture base was connected to the ADFG through a disposable nylon thread and attachment grip to pull the denture base vertically. The MBA and HBA test conditions were studied in the same manner, and the denture adhesive was wiped off completely from the intaglio surface of the denture base and the participant's maxillary edentulous arch between the testing procedures. The retentive readings were measured in newtons. The procedure was repeated 3 times at 10-minute intervals for both the control and test conditions. The average retention values of all conditions were compared using repeated-measures ANOVA with statistical software (IBM SPSS Statistics v22.0; IBM Corp) ( $\alpha=.05$ ).

## RESULTS

A total of 20 participants were included in the study (9 men and 11 women), with mean  $\pm$ SD age 68.20  $\pm$ 7.27. The average retention values for the MB and HB control conditions and the MBA and HBA test conditions are shown in Figure 4. Significantly higher retention values were recorded for the MB condition at 74.14  $\pm$ 33.51 N ( $P<.001$ ) compared with all other conditions (HB=54.23  $\pm$ 27.36 N, MBA=58.79  $\pm$ 32.43 N, and HBA=52.81  $\pm$ 24.23 N). When adhesive was used, no significant increase in retention means was seen with the MBA condition compared with the HBA condition ( $P=.088$ ). Moreover, no significant difference was found between HB and HBA conditions ( $P=.570$ ).

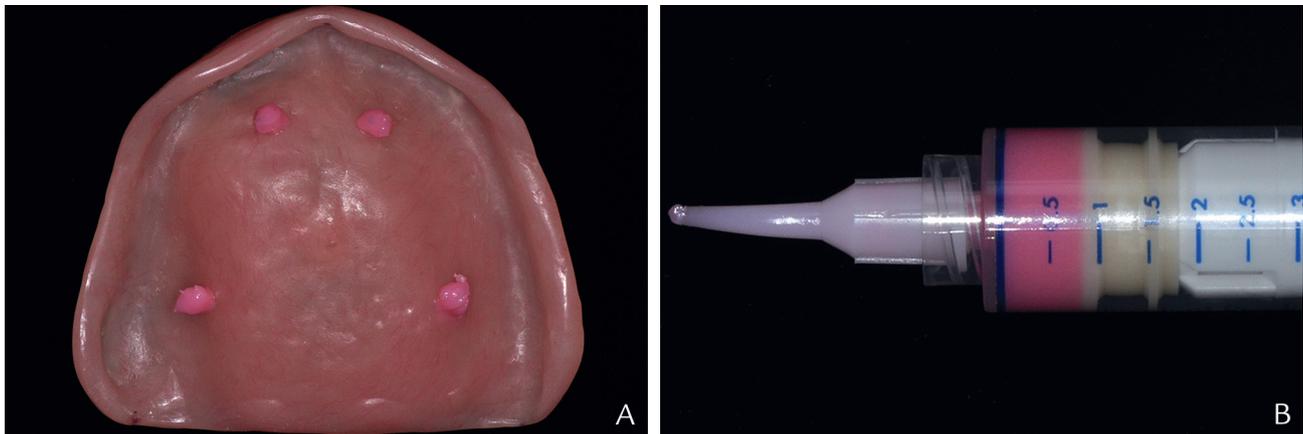
## DISCUSSION

In a previous study that compared the retention of milled and heat-activated resin bases,<sup>27</sup> MBs showed significantly greater retention than HBs. In the present study, significantly lower retention was recorded with MBs when denture adhesive was used compared with no denture adhesive. Therefore, denture adhesive performs negatively when a newly milled CD is provided. However, when denture adhesive is perceived as being needed by a patient, MBs with adhesive have no significant retention values compared with HBs. Instead, no significant differences in retention means were found between HBs, regardless of the use of denture adhesive. Those findings could directly relate to the methods of denture base fabrication. Given the excellent, intimate fit

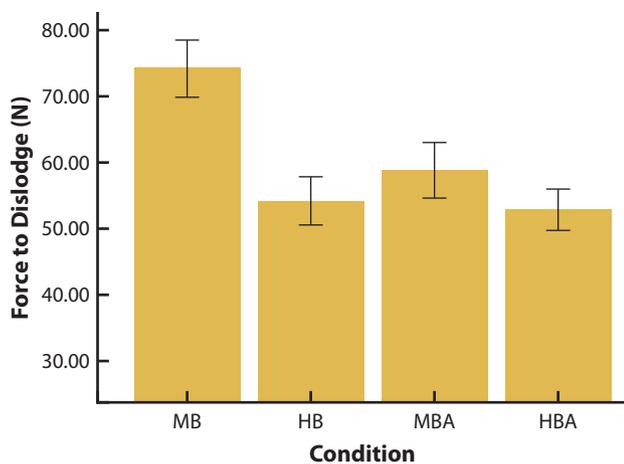
between the MB and the edentulous maxillary arch, the retention of a digitally milled CD may be negatively affected when denture adhesive is used, particularly in the form of 4 dabs, as used in this study. However, because of the polymerization shrinkage that occurs during the fabrication of HBs, the denture adhesive may effectively compensate for differences in fit, as shown in previous studies.

Ghani and Picton<sup>12</sup> compared the retention of ill-fitting maxillary CDs with multiple types of denture adhesives at different time intervals. They concluded that retention values with only saliva are significantly lower compared with adhesive. Psillakis et al<sup>13</sup> reported a significant improvement in occlusal force dislodgment when adhesive was used with the patient's existing maxillary CD. Patients reported greater satisfaction with denture performance and more confidence in their prostheses when adhesive was used. Ozcan et al<sup>14</sup> and de Baat et al<sup>15</sup> reported similar findings when adhesive was used for existing and new maxillary CDs. However, there was a noticeable increase in occlusal force for denture displacement with existing CDs compared with new CDs. Regardless of the denture adhesive type, Polyzois et al<sup>16</sup> reported a significant increase in the resistance of new and existing maxillary CDs to dislodgement forces compared with those with no adhesive. Similar results were found by Mañes et al<sup>17</sup> when the existing mandibular CD of a patient was used. Kalra et al<sup>18</sup> demonstrated significant improvement in incisal occlusal force of maxillary CDs when adhesive was used. Polyzois et al<sup>19</sup> compared the effect of denture adhesives on the dislodgment forces of new CDs immediately after placement and 30 days and 45 days afterward. They found the dislodgment forces of new CD at 90 days were significantly higher than those at 0 and 45 days, but they found no significant differences among the types of denture adhesive. Munoz et al<sup>20</sup> found a significant increase in retention when denture adhesive was used for well-fitting CDs compared with only saliva (control).

Previous studies focused on the effects of multiple types of denture adhesives when used with HBs. In this study, the focus was on evaluating the effect of 1 type of denture adhesive on 2 types of denture bases. The present study conflicted with the findings of previous studies<sup>12-20</sup> that concluded there was significant differences in the mean retention values among HB conditions. The differences in testing methodology can affect the denture base retention outcome of this study. Several previous objective clinical studies<sup>12,16,18-22</sup> used different devices in the testing procedure that included a UCL Retentiometer,<sup>12</sup> disposable gnathometer,<sup>16,18-21</sup> electronic gnathodynamometer,<sup>21</sup> and spring scale.<sup>22</sup> However, these devices were not designed to measure the retention in the vertical direction. In the present study, the testing device was designed to measure the



**Figure 3.** A, Denture intaglio with adhesive applied in 4 locations. B, Serial plastic syringe to standardize quantity of paste.



**Figure 4.** Retention of tested groups. Error bar indicates standard deviation. MB, milled bases; HB, heat-activated bases; MBA, milled bases with adhesive; HBA, heat-activated bases with adhesive.

dislodgment of the maxillary denture base only in the vertical direction.

The performance of digitally milled denture bases has been evaluated in clinical studies.<sup>23,25,29,30</sup> Kattadiyil et al<sup>25</sup> compared heat-activated CDs and 2-visit digitally milled CDs for 15 patients treated by predoctoral students. The authors concluded that there was a significant increase in retention, mastication comfort, and technique efficiency related to the digitally milled CDs. Moreover, absence of a PPS did not disturb the retention of digitally milled CDs. Bidra et al<sup>29</sup> compared the outcome of CAD-CAM monolithic dentures at time of placement and after 1 year. They reported a 79% increase in satisfaction with the overall experience as reported by patient-centered outcomes at follow-up.

Saponaro et al<sup>30</sup> completed a retrospective study of 48 patients who received milled CDs between 2012 and 2014. Twenty-four patients were treated by graduate students and 24 by predoctoral students. Thirty-one of 48 patients were satisfied with the 2-appointment

protocol for milled CD fabrication. However, 17 patients needed more than 2 visits. The most common clinical complications were lack of CD retention at the day of placement, followed by an increase in occlusal vertical dimension. The authors attributed those complications to the lack of a PPS, inaccurate definitive impressions, and inexperienced operators. Schwindling and Stober<sup>31</sup> compared 2 types of digitally designed CDs: milled from prepolymerized polymethyl methacrylate setting or injection molded for 5 patients. The authors reported no significant functional differences between the systems. Moreover, for less experienced operators, additional appointments may be needed to improve the esthetic outcome.

Recently, a systematic review of the clinical outcomes of computer-engineered CDs<sup>32</sup> found a significant reduction in clinical time and an increase in retention for the digitally milled CDs compared with heat-activated CDs. Also, patient selection might influence satisfactory outcomes.

In the present study, the denture base was seated for 5 minutes before the testing procedure, with 10-minute intervals between the testing procedures. The interval time was selected to allow the soft tissue to rebound to its original shape. No significant variation was noticed between the time intervals. This finding may indicate the soft tissues can rebound within only 10 minutes of removing the denture base.

The majority of the patients (80%) in the present study had type A and B residual ridge morphology in the maxilla, but none had a type D morphology, which is considered to be the least efficient type of ridge.<sup>16</sup> The results could have been different if type D morphology ridges had been tested.

This study was limited to 1 denture adhesive and 2 types of denture base materials. Future studies should include multiple denture adhesives and additional methods of fabricating denture bases, various time intervals, and longer seating times for denture bases.

## CONCLUSIONS

Within the limitations of this clinical study, the following conclusions were drawn:

1. Denture adhesive application decreased the overall retention of milled denture bases compared with retention when no adhesive was used.
2. The use of denture adhesive did not significantly improve retention values between milled and heat-activated resin bases.
3. The retention of heat-activated bases was not significantly increased by using adhesive as applied in this study.

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