THE JOURNAL OF PROSTHETIC DENTISTRY

CLINICAL RESEARCH

Comparison of retention between maxillary milled and conventional denture bases: A clinical study

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ABSTRACT

Statement of problem. Clinical studies comparing the retention values of milled denture bases with those of conventionally processed denture bases are lacking.

Purpose. The purpose of this clinical study was to compare the retention values of conventional heat-polymerized denture bases with those of digitally milled maxillary denture bases.

Material and methods. Twenty individuals with completely edentulous maxillary arches participated in this study. Definitive polyvinyl siloxane impressions were scanned (iSeries; Dental Wings), and the standard tessellation language files were sent to Global Dental Science for the fabrication of a computer-aided design and computer-aided manufacturing (CAD-CAM) milled denture base (group MB) (AvaDent). The impression was then poured to obtain a definitive cast that was used to fabricate a heat-polymerized acrylic resin denture base resin (group HB). A custom-designed testing device was used to measure denture retention (N). Each denture base was subjected to a vertical pulling force by using an advanced digital force gauge 3 times at 10-minute intervals. The average retention of the 2 fabrication methods was compared using repeated ANOVA (α=.05).

Results. Significantly increased retention was observed for the milled denture bases compared with that of the conventional heat-polymerized denture bases (P<.001).

Conclusions. The retention offered by milled complete denture bases from prepolymerized poly(methyl methacrylate) resin was significantly higher than that offered by conventional heat-polymerized denture bases. (J Prosthet Dent 2017;117:233-238)

Historically, bone, wood, ivory, porcelain, vulcanite rubber, metals, and polymers have been used to fabricate removable complete dentures (CDs), with presently, poly (methyl methacrylate) (PMMA) being the most widely used.[1-3] Various methods are now available for the fabrication of PMMA CD bases using heat-, chemical-, light-, or microwave-polymerization and rapid prototyping or milling by computer numeric control (CNC).[2,4-6]

The recently introduced method of milling denture bases using computer-aided design and computer-aided manufacturing (CAD-CAM) for digital complete dentures has advantages.[4,5,7-9] These advantages include reduced clinical chair time (2 appointments) for denture fabrication and placement; the ability to provide a replacement or a spare prosthesis by using the stored digital data; high strength and density; and the lack of polymerization shrinkage of the acrylic resin.[8] The CAD-CAM method of fabrication also eliminates the in-house laboratory work time, reducing the technician's workload.[4]

Jacobson and Krol[10-12] reported that the fabrication of a successful CD requires satisfactory stability, support, and retention. The importance of retention has been discussed in other articles along with its effect on successful CD therapy.[13-19] Several methods and devices have been used to test CD retention.[20-28] In addition, posterior palatal seal design, palatal tissue surface design with or without relief, denture base surface enhancement with airborne particle abrasion, and adhesives have been

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Clinical Implications

The choice of a milled denture base might be appropriate when limited retention for the maxillary arch is expected. The increased retention of milled denture bases for the maxillary arch could provide improved fit and retention.

reported to improve CD retention.[20-28] Obtaining excellent adaptation and maximum achievable coverage of the denture base is also an important retention factor.[29]

Denture base adaptation can be influenced by the amount of polymerization shrinkage that occurs during processing.[30-35] However, CAD-CAM dentures milled from prepolymerized PMMA blocks do not exhibit polymerization shrinkage. The purpose of this clinical study was to compare the retention values of maxillary conventional heat-polymerized denture bases with digitally milled denture bases. The null hypothesis was that no differences in retention would be found between maxillary digitally milled and conventional heat-polymerized denture bases.

MATERIAL AND METHODS

Approval was obtained from the Institutional Review Board of Loma Linda University before conducting this study. Twenty maxillary edentulous participants (11 men and 9 women, average of 68.20 ±7.27 years of age) signed informed consent forms before participating in this study.

For the inclusion criteria, participants needed to be of legal age (above 18 years of age) to provide consent and had been completely edentulous in the maxillary arch for a minimum period of 1 year (Fig. 1A). Exclusion criteria included the presence of ridge or soft tissue pathology, reduced salivary flow, a history of taking medication that would alter the quantity and quality of saliva, the presence of severe ridge undercuts, and palatal tori that required surgical correction.

A preliminary impression was made at the first visit, using an irreversible hydrocolloid impression material (Jeltrate; Dentsply Caulk). The preliminary impression was poured according to manufacturer's instructions with Type III dental stone (Microstone; Whip Mix Corp). Custom trays were fabricated from Triad light-polymerized material (Tru Tray Sheet; Dentsply Intl). The custom trays were trimmed to 2 mm shorter than the vestibular sulcus to allow for border molding.

For the second visit, the participants were instructed not to wear their complete denture 24 hours before the appointment. A heavy body polyvinyl siloxane impression material (Aquasil; Dentsply Intl) was used to border mold the trays, and a definitive impression was made with a light body polyvinyl siloxane impression material (Aquasil; Dentsply Intl). The posterior palatal seal area was delineated on the maxillary impression by using a protocol outlined by Hardy and Kapur.[19] Melted impression wax (Korecta extra soft; Patterson Dental Supply Inc) was used for the definitive posterior palatal seal impression by applying it to the impression and reseating it in the participant's edentulous maxilla to record the definitive design and form of the posterior palatal seal. Any excess wax was then carved away (Fig. 1B). The definitive impression was scanned (iSeries; Dental Wings) within 24 hours to capture the impression details (Fig. 1C). The standard tessellation language file of the scanned maxillary impression was sent to Global Dental Science, LLC (GDS) for the fabrication of the milled denture bases (group MB) (AvaDent; Global Dental Science LLC) (Fig. 1D). After scanning, the impression was poured in Type III dental stone (Microstone; Whip Mix Corp) to fabricate a definitive cast (Fig. 1E). The definitive cast was used to fabricate a heat-polymerized acrylic denture base (group HB) resin (Lucitone 199; Dentsply Intl) (Fig. 1F). The conventional heat-polymerized denture bases were processed using a long polymerization cycle, 9 hours in a water bath at 73°C ±1°C, followed by 30 minutes in boiling water as recommended by the manufacturer.

Each edentulous maxillary arch type was classified according to McGarry et al[36] regarding the vestibular depth, ridge morphology, maxillary tuberosity, hamular notches, and presence of tori and/or exostoses (Table 1). The maxillary arch and palatal throat form were classified and recorded based on the classification by House[37] (Table 1).

Each denture base was inspected and seated intraorally. Adjustments were made using pressure indicator paste (Henry Schein Inc) to detect areas of impingement and then relieved. Participants were asked to also provide verbal feedback regarding areas of discomfort, and those areas were identified with pressure indicator paste and relieved. A stainless steel snap hook attachment with standardized weight and dimensions was fixed in the center of the denture base, using autopolymerizing acrylic resin (Fig. 2) for 10 minutes at 100 kPa pressure in 43°C water according to the manufacturer's instructions (Lucitone 199 Repair Material; Dentsply Intl).

The center of the denture base was located on the definitive cast by marking the center of the labial frenum (Fig. 3, point A) and the pterygomaxillary fissures (Fig. 3, points B and C). The distance halfway between Figure 3 points B and C was measured, and the location marked on the posterior border of the denture base (Fig. 3, point D). Finally, half the distance between point A and D was marked as the center of the denture base (Fig. 3, point E).

The testing device consisted of 4 parts: a digitally advanced force gauge (DAFG; Series 5 force gauges; Mark-10 Corp) (Fig. 4A) to read the force, with ±0.01 N accuracy, required to dislodge each denture base from the

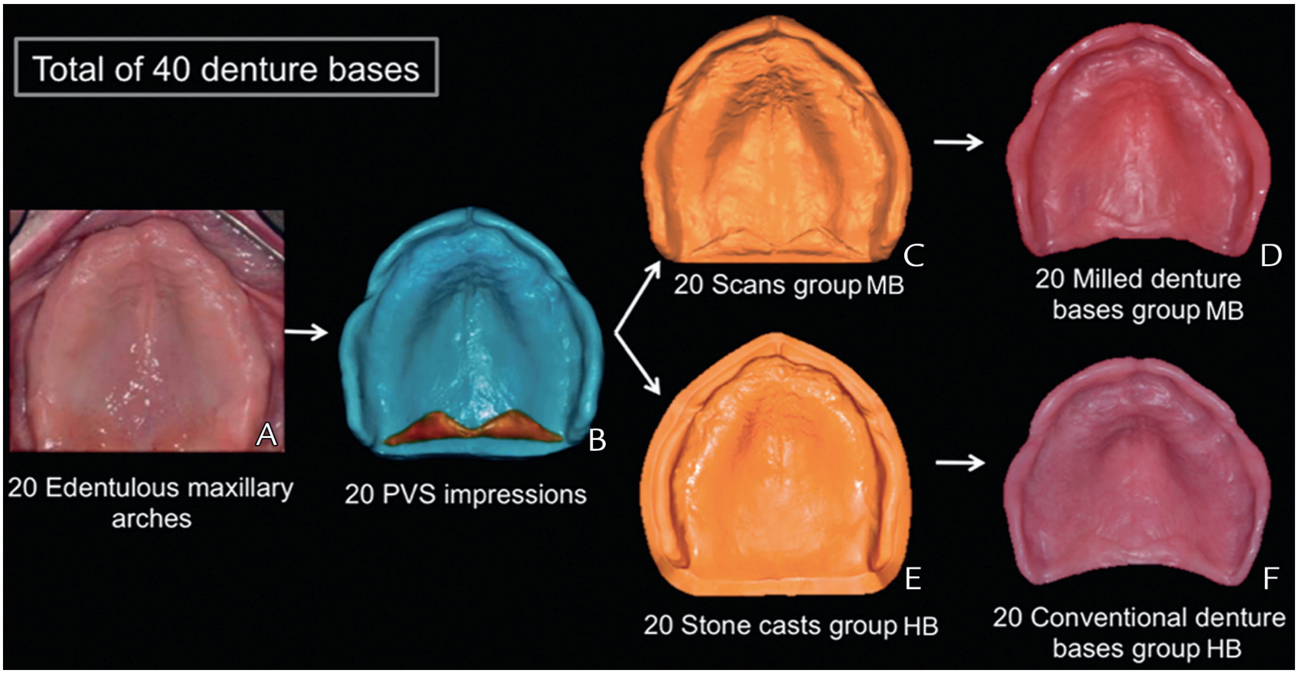

Figure 1. Study design and groups. A, Maxillary edentulous arch. B, Definitive PVS impression with definitive form of posterior palatal seal. C, Scan of maxillary definitive PVS impression. D, Milled maxillary AvaDent denture base. E, Definitive stone cast. F, Conventional heat-polymerized denture base. PVS, polyvinyl siloxane.

Table 1. List of participants and their characteristics

Characteristic	n	%
Age (y), mean ±SD	68.20 ±7.27	
Sex		
Male	11	55
Female	9	45
Ethnicity		
White	13	65
Hispanic	3	15
African American	2	10
Hawaiian	2	10
Arch form		
Round	8	40
Square	8	40
Tapered	4	20
Maxilla type		
A	9	45
B	7	35
C	4	20
House palatal throat form		
I	7	35
II	7	35
III	6	30

Total sample size 20 participants.

edentulous ridge; a motorized test stand (Fig. 4B) (ESM301L; Mark-10 Corp) set at a crosshead speed of 50.8 mm/min standardizing the pulling rate for all the participants allowing the standardized collection of data with the participant sitting in an upright position (Fig. 4C); a force transmission device (FTD) (Figs. 4D and 5A) made of an autoclavable hollow aluminum rod with a pulley at each end; and a Panadent facebow (Panadent Corp) (Fig. 4F). The DAFG was anchored to the motorized test stand for stability. The force was transferred horizontally by using a disposable nylon thread (Tuf-Line; Western Filament Inc). The nylon thread connected to a hook centered on the denture base and the FTD directly below the denture base resulted in vertical force delivery. The nylon thread passed though the hollow FTD and attached to the DAFG through an adjustable vice (Fig. 4E) on the other side. Vertical height adjustment for each participant was obtained by moving the chair up or down. Horizontal adjustment was achieved with 4 adjustable knobs located in the FTD (Fig. 5A). This adjustability ensured a vertical pulling force (Fig. 5B, C). For a pulley system like this, the input force equals the output force only when the force delivery is vertical. The FTD was autoclaved, and the nylon thread was replaced after testing each participant. The modified Panadent facebow was mounted perpendicular to the floor which allowed orientation and stabilization of the participant's head relative to the Frankfort horizontal plane. The facebow was oriented parallel to the horizontal plane using a bubble gauge (Panadent Corp) (Fig. 5D).

Participants were instructed not to wear their prosthesis for 24 hours before the testing appointment. Each denture base was stored in water immediately after fabrication and remained immersed until testing was

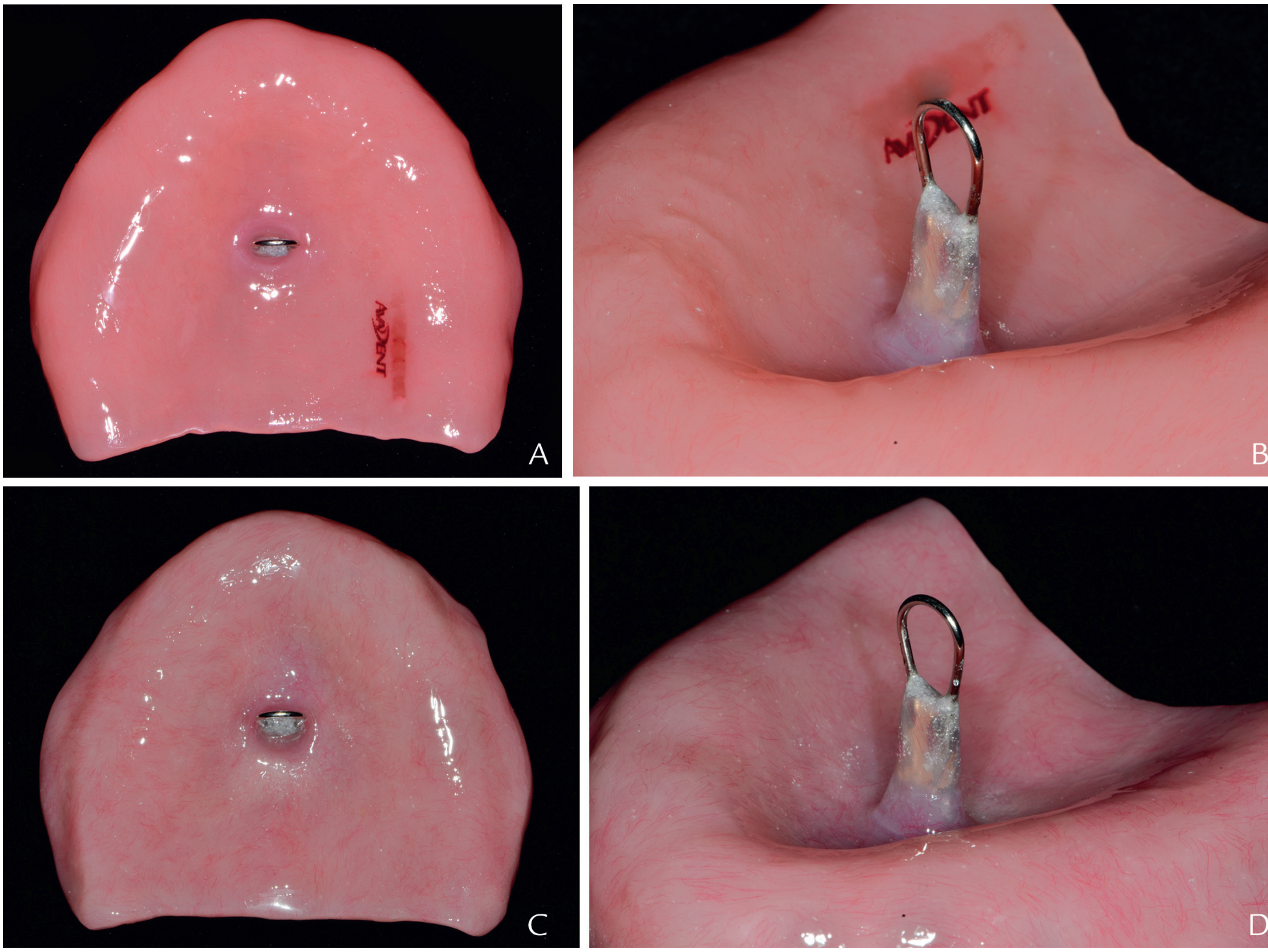

Figure 2. Stainless steel hook attached to denture bases. A and B, Representative milled denture base group. C and D, Representative conventional heat-polymerized group.

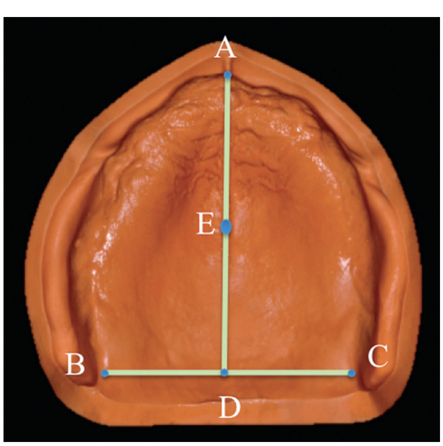

Figure 3. Method used in locating center of denture base. Center of labial frenum (A). Pterygomaxillary fissures (B, C). Distance halfway between points B and C (D). Center of denture base (E).

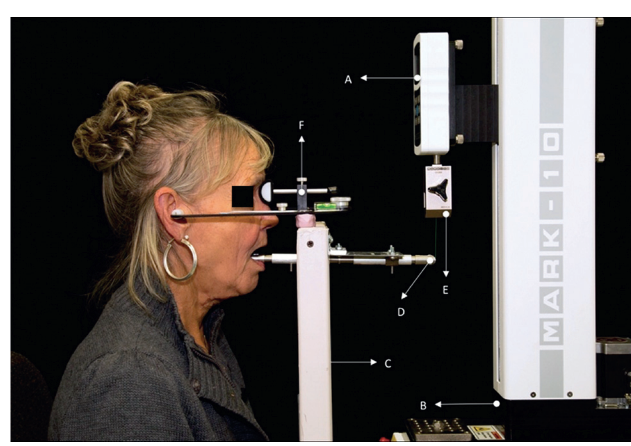

Figure 4. Testing apparatus. Digital advanced force gauge (A). Motorized test stand Mark-10 extended length ESM301L (B). Wood stand (C). Force transmission device (D). Grip attachment (E). Panadent facebow (F).

completed. Finger pressure was applied to seat each denture base firmly over the edentulous maxillary arch, and tissues were then allowed to settle and rebound for 5 minutes before testing started. The nylon thread attached to the hook on the denture base was then subjected to the vertical pulling force, using the testing assembly. This

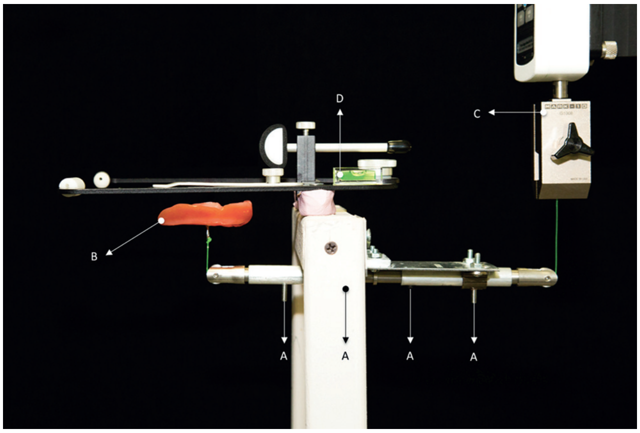

Figure 5. Force transmission device. Four adjustment knobs (A) for horizontal distance orientation. Denture base (B) subjected to vertical dislodgment force. Attachment grip (C) exerting pulling vertical dislodgment force. Bubble gauge (D) confirming parallel alignment of Panadent facebow and force transmission device to floor.

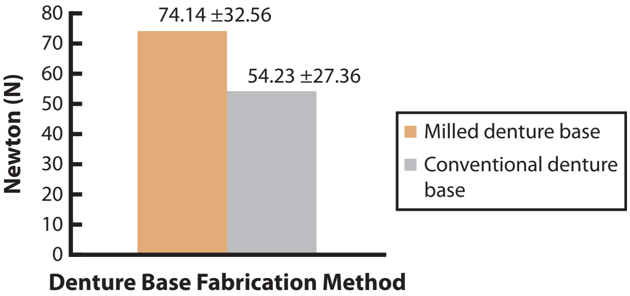

Figure 6. Retention of milled and conventionally heat-polymerized denture bases.

procedure was repeated 3 times at 10-minute intervals for each denture base, and all retentive values were recorded in newtons (N). The testing procedure was performed by alternating between the 2 groups (group MB and group HB) throughout the study. The average retention of the 2 fabrication methods was compared using repeated measures analysis of variance (ANOVA; α=.05).

RESULTS

The average retention values for the milled denture bases (group MB) and the heat-polymerized denture bases (group HB) are illustrated in Figure 6. A significant increase of 19.91 N (*P*<.001) was noted in retention for the MB group compared with the conventional polymerizing method. Average retention for the MB group was 74.14 ±32.56 N, and average retention for the conventional HB group was 54.23 ±27.36 N (Fig. 6).

DISCUSSION

The null hypothesis that no differences would be found in retention between maxillary digitally milled and conventional heat-polymerized processed denture bases was rejected. Increased retention with milled CDs has been previously reported as a possible advantage of digital dentures.[4,8] Kattadiyil et al[8] reported significantly higher retention for digital dentures than for conventional complete dentures. Their study was conducted in a predoctoral setting where each patient received a set of digital CDs and conventionally fabricated CDs. Faculty evaluation determined significantly higher retention, fit, stability, and superior denture base contour. A patient questionnaire was also given to each patient after wearing both dentures, each denture for a week. Patient satisfaction with the digital CDs was significantly higher than that with the conventionally processed CDs in terms of comfort, retention, masticatory efficiency, prostheses selection, and efficiency of technique. The methodology used to assess retention by Kattadiyil et al[8] was an objective clinical examination by faculty using grading criteria and biofeedback from patients on a Likert scale. In the present study, a specially designed testing device calibrated to perform force measurements was used to determine denture base retention. This device was easily portable, which allowed intraoral clinical measurements. Despite the differences in methodology, the results of the study by Kattadiyil et al[8] and the present study revealed similar significantly higher retention for maxillary digital denture bases. This is most likely because the lack of polymerization shrinkage associated with milled denture bases results in an improved fit, thereby improving retention.[4,5,8]

Multiple methods and devices have been proposed to measure the amount of retentive force needed to dislodge a denture base intraorally,[20-28] including a variety of devices that use either a pulley system with a weighing pan, spring balance, spring gauge, spring scale, strain gauge force transducer, retentiometer, dynamometer, or gnathometer.[20-28] However, these devices and methods were not necessarily designed to deliver the dislodgment forces in a vertical direction, nor were they standardized to deliver the dislodgment force at a constant speed, which is critical in a pulley system.[20-28] As far as the present authors are aware, this study was the first to use standardized vertical forces to measure retention values for maxillary denture bases.

PMMA shrinkage can cause denture distortion because of volumetric and linear polymerization shrinkage.[3,30-35] Traditionally, this has been negated by hydrating the denture bases in water.[3] The resulting expansion due to hydration may counter the influence of polymerization shrinkage, depending on the amount of residual monomer.[3] We used the same protocol for both of the denture bases. Each denture base was stored in water immediately after its fabrication. However, the clinical result showed a significant increase in retention for the prepolymerized compared with the conventional HB group. Therefore, the hydration might not have sufficiently compensated for the polymerization shrinkage as shown by the lower retention values recorded for the conventional group. One possible explanation for this could be the increased density of the milled denture bases, as they are fabricated from a dense block of prepolymerized acrylic resin offering higher dimensional stability and not necessarily influenced by hydration. The effect of hydration on density could be studied in the future to determine its potential effects on denture base adaptation.

A limitation of this study was that participants were tested at 10-minute intervals instead of a longer period to control for the total testing time for participant convenience. This interval of time might not have been sufficient for soft tissues to conform to their original shape and so could have affected the outcome. However, no significant variations were seen between the 10-minute intervals.

This clinical study attempted to assess objectively whether a difference in retention could be found between conventional heat-polymerized denture bases and prepolymerized milled denture bases in the maxilla. It would be of interest to study retention in the mandible to determine whether differences exist because of base fabrication methods. However, the presence of unfavorable surface areas and difficulty in centralizing forces because of the presence of the tongue would contribute to study complexity but offer thoughts for consideration when designing such a study in the future.

CONCLUSIONS

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

1. The retention offered by milled prepolymerized PMMA complete denture bases was significantly higher than that of conventional heat-polymerized denture bases.
2. A milled denture base might be an appropriate choice when increased retention is required.

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Acknowledgments
The authors thank Dr Mathew M. Alani for input regarding the pulley system design used in this study.