Case Report

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Posterior Palatal Seal Area Established in Conventional and CAD/CAM Fabricated Complete Denture Techniques: Clinical Case Study

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Abstract

Statement of problem: Deformation of heat-polymerized PMMA denture bases during its fabrication may affect posterior palatal seal (PPS) of maxillary dentures due to unavoidable dimensional changes such as contraction on cooling and polymerization shrinkage. Overcoming of this shrinkage encountered in conventionally processed completed dentures may improve the fit of the denture base of CAD/CAM processed complete dentures. Clinical studies are lacking in comparing and relating the frictional denture retention due to good border seal for both CAD/CAM processed denture bases and conventionally processed denture bases.

Purpose: In this comparative study, retention of maxillary complete denture is evaluated in terms of PPS for both conventional and CAD/CAM processing techniques. This clinical report describes the manufacturing of a removable CAD/CAM complete denture made of high density polymer to enhance the predictability of retention.

Material and methods: Vertical dislodging forces were applied to both types of maxillary complete denture bases at a preselected middle location. A specially designed strain gauge force meter was used to dislodge the two different denture bases. Forces dislodging each denture base were recorded and the mean retentive force of the 2 techniques was compared (Wilcoxon Z test).

Results: Retention of maxillary CAD/CAM denture base was increased as compared to that of conventionally processed one. A significant difference was noted in vertical pulling force for the CAD/CAM denture base as compared to conventional denture base.

Conclusion: Using the CAD/CAM complete denture increased frictional retention and stability and improved its clinical performance due to good base adaptation and border seal. Patient may thereby benefit from this more retentive and more durable denture.

Keywords: Posterior palatal seal (PPS); CAD/CAM fabrication techniques; Retention; Polymerization shrinkage

Introduction

Denture retention stands for the force needed to entirely remove a denture from its basal seat [1]. The most common factor resulting in lack of retention of maxillary complete denture is failure to utilize proper anatomical and physiological landmarks as well as recording PPS. Physical forces determining the retention of a complete denture are surface tension, adhesion, cohesion, saliva film thickness, and atmospheric pressure. Retention is improved as interfacial film thickness is reduced and a thin film of saliva exists between the mucosa and the tissue surface of the denture. The force needed to displace a denture is inversely proportional to the thickness of saliva film between the denture and the tissues [2,3]. Acrylic resin volumetric shrinkage-exists during polymerization process-is due to the differences in densities of the monomer and the polymer [4,5] and may result in elevating of the denture base away from the posterior palate after polymerization. The posterior mid palatal area undergoes the greatest distortion [6-8]. Special impression techniques of determining and establishing of PPS seal are used to neutralize the dimensional changes that may occur during acrylic resin processing [3]. Dentistry has not been exempted from changes in this era of technology-driven revolution. Entire workflows are already digitalized, and restorations are manufactured using computer-aided solutions. Digital methods for complete denture construction are growing slowly due to perplexed or irregular profile of complete dentures and the diversity of materials used for their application [9]. Computer-aided design and computer-aided manufacturing (CAD/CAM) recently provides milling of variety of materials for prosthodontic applications. CAD/CAM polymers were introduced for dental restorations, which can be processed more rapidly and at a lower cost [10]. Resin CAD/CAM blocks were cured at high temperature and pressure under controlled conditions, resulting in consistent mechanical properties and higher flexural resistance than conventionally polymerized blocks [10,11]. CAD/CAM technology is commercially obtainable in the past few years for construction of complete dentures through the introduction of AvaDent digital dentures (Global

Dental Science LLC, Scottsdale, Ariz.). This technology undertakes the precision and appearance of CAD/CAM process automation to removable dentistry [12-14].

AvaDent digital dentures, whose name is derived from Ava meaning rebirth and Dent meaning dentition [15], make it likely for the patient to obtain a more fitting denture in 2 visits. Instead of a 5-visit lengthy procedure used with conventional complete dentures. CAD/CAM system used a two-visit technique as impressions, jaw relations and selection of teeth are fulfilled in only one visit. Dentures are then constructed using CAD/CAM technology and inserted at the second visit [12-14,16].

With the introduction of these commercially available systems, the recent era of digital complete dentures has arrived. The purpose of this study was to compare the retention as evidenced by PPS captured for both conventional and CAD/CAM maxillary complete dentures.

Material and Methods

Clinical report

A 60-year-old completely edentulous patient was referred to the Department of Prosthodontics at Dammam University in Dammam. The patient had a moderate palatal vault depth with no severe maxillary undercuts. The quality of saliva was neither watery nor viscous. He had no experience with previous dentures and without soft tissue pathology. Two dentures were constructed for the patient, one processed conventionally and the other one processed using the CAD/CAM system.

Conventional complete dentures: Impressions were made using polysulfide rubber impression material (Permlastic™). Impressions were poured in stone. PPS is established by scraping the cast according to Winkler [17] as follows: the displaceable tissue in the area of the posterior palate was palpated and outlined with an indelible marker. The mark was transferred to the master cast using trial denture base. The vibrating line was made visible as the patient blowing his nose. Vibrating line was identified by asking the patient to say “AH” in short bursts. Cast is scored. The deepest area of PPS was located on either side of midline. It was scraped to a depth of 1 mm to 1.5 mm. Dentures were processed using heat-curing acrylic resin (Lucitone, L. D. Caulk Co., Milford, DE, USA) by placing the flasks in a constant-temperature water bath [Hanau Curing Unit, Hanau Engineering Company Inc, Buffalo, USA] at 74°C for 2 h then boiling at 100°C for 1 hour [18]. Dentures were checked clinically and the intaglio surface was evaluated with pressure indicating paste (M&Y Inc., Clifton Forge, VA).

CAD/CAM complete dentures were delivered to the patient through 2 visits.

Visit-1

Customizing stock trays: Putty casts was obtained by squeezing mixed poly (vinyl siloxane) putty into the tissue surfaces of the patients first delivered conventional dentures. Adapted trays were adjusted over putty casts, and then in the patient’s mouth. Overextension or under extension adjustments were done if needed (Maxillary tray must cover vibrating line and hamular notches and Mandibular tray covers retromolar pads). Vibrating line was determined by asking the patient to cough or by saying the word “AH”.

Making maxillary and mandibular final impressions: Peripherally molded final impressions were obtained using medium-body poly (vinyl siloxane) impression material. PPS was identified by marking the vibrating line with a different colored marker, and the maxillary final impression re-inserted to transfer the position of the proper PPS to the maxillary impression.

Jaw relation records: Anatomical measuring device (AMD) was used to record jaw relations (it consists of an upper tray with a stylus positioned at the center of the tray and a lower tray having a tracing plate and an occlusal plane ruler and an integrated Gothic arch device).

Alignment of maxillary AMD with the interpupillary line is recorded through occlusal plane ruler. Maxillary and mandibular AMDs were positioned parallel to each other.

Existing conventional dentures with occlusal contact are used as a guide to maintain the same vertical dimension on proposed CAD/CAM dentures.

The adjustable screw in the upper tray contacts the lower tracing plate at the same accepted vertical dimension to record centric relation using the incorporated Gothic arch device. The patient is guided to this accepted centric relation as the upper stylus engaging the recess in the lower tracing plate at the established occlusal vertical dimension.

Maxillary anterior teeth positioning: Midline is marked and the size of maxillary anterior teeth is also determined. Interocclusal vinyl polysiloxane material is injected between maxillary and mandibular arches while the stylus is in its recess in centric relation so that the AMDs are firmly interlocked. Final impressions and connected AMD trays are sent to the global dental science, LLC, producer of AvaDent digital dentures so that laser scanning will be performed to format occlusal relationship of the arch morphology.

Computer software is used to identify the borders of the denture and artificial teeth will occlude virtually to the proper occlusal plane and the established denture base. Accordingly, milled denture base will have suitable recesses to accommodate each denture tooth. Artificial teeth are bonded in their planned position using a suitable bonding agent.

Visit-2

Insertion

Insertion and post-insertion procedures of CAD/CAM complete dentures are followed as those performed for the insertion of conventional dentures.

Retention force measurements: The patient was allowed to wear first, his conventional acrylic dentures for 2 weeks during which the evaluation parameters were measured. Then the dentures were removed from patient's mouth for one day as a period of rest. Then CAD/CAM dentures were secondly delivered. Data was collected for more two weeks and then analyzed. The patient was trained to manipulate either of the two sets of dentures (conventional and CAD/CAM dentures) in his mouth in the same manner until the denture attained a comfortable position.

The center of each fabricated maxillary denture was located on its definitive cast by marking a line from the tip of canine on the right side to the pterygomaxillary fissure on the left side. Another line was marked on the contralateral side. The geometric centre (on the polished mid-palatal surface) of each maxillary denture is the meeting point of the two lines on the midline (**Figure 1**).

Figure 1 Geometric centre (polished mid-palatal surface) of each denture is the meeting point of two lines on the midline.

A stainless-steel loop was fixed in this geometric center of the each maxillary denture base, by using autopolymerizing acrylic resin (Major Repair; Major Prodotti Dentari SPA, Italy)/10 minutes placed in the pressure chamber containing warm water (40°C), at pressure 30 IB/inch2 (pound-force per square inch).

A hook of strain gauge force meter was attached to this loop to detach the denture from the patient mouth and to record the force needed for vertical dislodgment (vertical pulling force) (**Figure 2**).

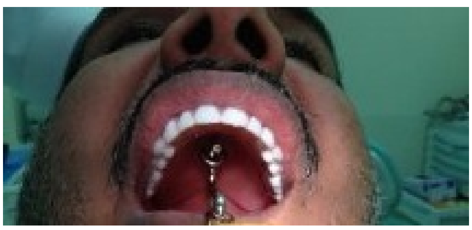

Figure 2 Hook in the geometric center of maxillary denture attached to strain gauge force meter.

This force meter consisted of two electrical resistant wire strain gauges, digital strain indicator unit (TQ Digital Strain Display-Tec Equipment, Ltd, Bonsall Street, Long Eaton, Nottingham NG10 2AN, UK), and X-Y chart recorder unit (**Figure 3**).

Figure 3 Digital strain indicator unit.

Vertical dislodging forces of the upper denture base would affect the cemented strain gauges to induce an output signal that was passed to the strain indicator unit.

Each fabricated maxillary denture was seated intraorally, and tissues allowed to rebound for few minutes before measuring vertical pulling force. This test was repeated 3 times a visit along 2 days for each denture base, and all 6 readings were recorded in grams (**Table 1**).

Table 1 Retention values in grams (vertical pulling force required to dislodge conventionally and CAD/CAM processed maxillary denture bases).

Readings	Maxillary Denture Base	
	Conventionally Processed	CAD/CAM processed
1	1370	2170
2	1350	2108
3	1345	2172
4	1408	2192
5	1312	2088
6	1375	2110
Mean	1360	2140
SD	32.43	43.03
Wilcoxon Z test	2.882	
P-value. (2-tailed)	0.004	

Wilcoxon Z test was used as a non-parametric test to disclose the average retention as to compare between the forces required to dislodge both types of denture bases at 5% level of significance.

Results

The average values of dislodgment (vertical pulling force) of both conventional denture base and milled denture base were illustrated in **Table 1 and Figure 4**.

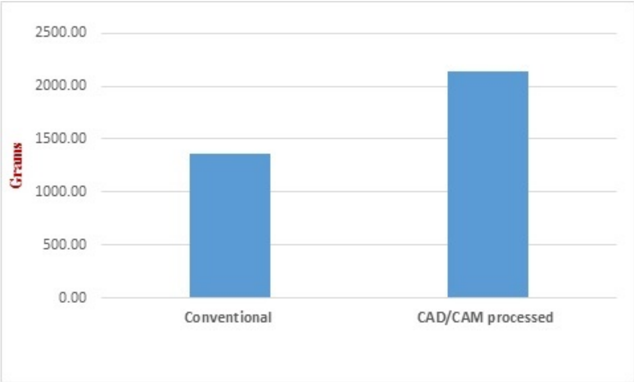

Figure 4 Retention values (Mean force required to dislodge the maxillary conventional and CAD/CAM processed denture bases).

It was shown that the average retention offered by CAD/CAM denture base (2140 g ± 43.03 g) was significantly higher than that noted with conventional denture bases (1360 g ± 32.43 g) where Z=2.882, P=0.004.

Discussion

One of the essential steps in the construction of maxillary complete denture is to establish the posterior length of its basal seat to develop the so-called PPS [17]. Polymerization shrinkage of conventional acrylic resin induces distortion of these denture bases as a result of inevitable thermal stress during denture processing [19]. Distortion during processing may breach the peripheral border seal and increase the volume of interior vacuum beneath the denture base which allowed ingress of air, saliva, and food particles that will compromise retention and stability of the denture base and may eventually result in an ill-fitting maxillary denture [20]. Adaptation accuracy of the denture base has become a focal point to shed the light over it in complete denture removable prosthodontics [21]. To date, no research is published comparing and evaluating denture retention in terms of posterior palatal seal for both CAD/CAM processed denture bases and conventionally processed denture bases.

Selective pressure impression technique was applied due to its excellent reproduction of surface details and good flexibility. Regular body polysulfide impression was recommended as an impression as having a high flow that will register the fine details and will not tear as removed from undercuts.

In conventionally processed completed dentures, polymerization shrinkage together with thermal contraction by flask cooling, and also strain resulting from stress release during deflasking may cause reduced adaptability of the denture base to the tissue. The familiar effect of this polymerization or linear shrinkage is occurring on the PPS area of the maxillary denture, which may result in a vacuum space between PPS and the denture base [22]. The largest denture base dimensional changes are observed in the denture PPS due to the feature of palatal configuration while polymerization or linear shrinkage occurring toward the residual ridge. This may lead to raising of the denture base in mid-palatal area [23]. Herewith, the disparity between the denture base and supporting tissue is an essential role for monitoring of stresses needed to dislodge the maxillary denture [2]. Better denture base adaptability to the tissues could improve complete denture retention. An understandable outcome of an appropriate denture base retention is more stability with less movement during function [24].

Kattadiyil et al. [14] concluded that cancellation of the polymerization shrinkage intrinsic in conventionally processed completed dentures may improve the fit of the denture base of CAD/CAM complete dentures. In the current clinical report, the pull end of the digital force-meter was connected to the hook positioned at the centre of maxillary denture and was pulled vertically until denture dislodgement occurred. This was in agreement with Figueiral et al. who measured denture retention clinically as his patients were subjected to vertical tensile tests by using an intraoral resistance transducer with four strain gauges forming a Wheatstone bridge to measure an electric resistance [25]. The volume of the vacuum space or gap between mucosa and the fitting surface of the denture base will be expressed in terms of measuring the degree of the denture fitting as controlling the air flow occurring there. The better the fitting of the denture base to the tissues, the better will be the resistance of the denture to displacement [26]. The center of the maxillary denture was determined from the center of a triangle defined by 3 anatomical landmarks (maxillary tuberosities and the interincisal papilla). A stainless-steel hook was fixed at this geometric center using auto polymerizing resin. The hook or loop was attached to a specially designed strain gauge force meter [25].

The patient was allowed to wear either of the two dentures for two weeks during which time a complete adaptation of the denture would occur. The strain gauge force meter recorded the force needed to dislodge the denture base from its basal seat. The force meter was calibrated at each test session. The patient did not complaint from the magnitude of force required to displace the denture base from its basal seat.

PPS is a valve seal area occurring between anterior and posterior vibrating lines at the distal border of the maxillary denture. If this distal border extends too far posteriorly beyond vibrating line, the seal is broken when the soft palate rises during deglutition and speech, and the denture will become loose and may drop; nausea may arise. If the posterior palatal border does not reach this compressible area, denture retention will be poor as the seal is inefficient and again the patient having nausea since the edge of the denture may irritate the posterior third of the tongue as it will not bed into the tissues. PPS provides sunken distal border that is less conspicuous to the tongue [27,28].

The depth and extent of PPS is best confirmed by assessing the color, resilience of the tissue and contact tolerance directly in the patient's mouth. Hard palate has keratinized displaceable mucosa but relatively well attached to withstand the pressures of mastication. This keratinization gives the hard palate mucosa a pale appearance compared with the pink non-keratinized mucosa on the mobile soft palate. The color change is a guide to the border between the hard and soft palates. The concept of scoring the cast to achieve PPS is a common practice for many years. Under-extension compromises retention, and overextension or sharply carved borders creates soft tissue trauma [29]. It is preferable to select the PPS area as a butterfly running up to 3 mm to 4 mm anterolateral to the tuberosity, approximating muco-gingival junction [17,29]. This area is considered as a compressible tissue lying at the junction of hard and soft palates. The pressure applied by the denture base at the PPS area will add to the denture retention as being within functional limits. There were substantial variations between all of the measurements of denture retention [30].

Recently, CAD/CAM technology is digitally obtainable for complete denture construction through which impressions, interocclusal records, and maxillomandibular relation records can be made in the first visit. Dentures are then constructed using CAD/CAM technology and inserted in the second visit [12-14]. Among the advantages of CAD/CAM complete denture is its possibility to record all clinical data in one visit (1-2 hours) and so clinical chair time is reduced considerably. As the denture is constructed by machining, resin polymerization shrinkage is precluded, with less porosity and more fitted denture base [12-14]. This outstanding strength and fit of dentures may be due to the use of previously polymerized acrylic blocks for milling [12,14,15,31].

Another advantage of digitally fabricated CAD/CAM maxillary denture is the absence of usual errors when establishing PPS area because there is neither wax nor physical casts which are used with conventional dentures [12-14]. An anticipated advantage of CAD/CAM denture is the minimal porosity that means a reduced potential for dentures to harbor microorganisms (such as *Candida albicans*) and minimizing resultant infections [12,31].

The pink denture base is digitally milled from a block of totally cured denture colored PMMA using CAD/CAM technology through a computer milling machine. Milling from a solid acrylic resin block of formerly cured acrylic resin is illustrated by Kraver [15] as no distortion occurred when it is milled out. As such, little or no shrinkage can be observed as a result of curing which may result in a more fitted denture base. The purpose of digital construction of complete dentures is to reduce the number of clinical visits as the treatment outcome will be accepted. The workflow is easier due to gathering of impression making and occlusal registration in a single step [32]. Design and extent of posterior palatal seal will affect the retention of maxillary denture. Incorporation of PPS compensates for shrinkage of the acrylic resin and maintains the denture-tissue interface, which is considered to be essential for complete denture retention [33].

This study showed that retention of maxillary CAD/CAM denture base increased significantly as compared to that of conventionally processed denture bases. This is in agreement with Kattadiyil et al. [34] who reported a significantly higher retention for digital dentures (or milled dentures) than for conventional complete dentures.

Application of CAD/CAM constructed dentures reduced the number of clinical visits to 2 only from the conventional 5-visits till the patient inserted the denture. Other advantages as evidenced by Kattadiyil et al. [14,34] are the improved denture fit due to lack of polymerization shrinkage and easy construction of a spare denture at any time from stored digital data. CAD-CAM constructed dentures provided the most consistent denture base adaptation as proved by Goodacre et al. in a recent *in vitro* study to be the most reproducible technique at the apex of the denture border and posterior palatal seal areas [35]. Milled denture bases offer higher strength and less distortion. Patient records are stored digitally, so, if a patient loses a denture, a new duplicate one will be constructed without new records. CAD-CAM construction denture base technique was considered to be the most accurate and reproducible technique as compared to conventional or traditional processing techniques [33,35]. A systematic review of complete denture construction technique using CAD/CAM technology by Bidra et al. [31] reported that predictable clinical trials are lacking in this rapidly improving digital application and that more scientific research is needed in this regards [14].

Conclusions

Accurate determination of posterior palatal seal is the responsibility of the dentist and not a commitment of the dental technician. Retention acquired with CAD/CAM or digital complete denture bases was significantly higher than that offered by conventional complete denture bases. CAD/CAM processed complete denture base may be considered as a suitable choice when more retention is needed. As the established clinical records, can be obtained in one visit and the dentures will be inserted in the second visit, there is less clinical time concerned in the overall treatment. More research should be applied to evaluate the complete dentures constructed using CAD/CAM technology, to identify the arrangement of artificial teeth using a virtual cast and virtual articulator, and also to search for new denture base materials readily applicable for this concern.

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