Effect of Different Techniques for Palatal Denture Base Configuration on Speech Quality in Complete Denture Wearer

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Abstract

Purpose: The purpose of this study was carried out to evaluate the effect of different techniques for palatal denture base configuration on pronunciation of different speech sounds in complete denture wearer.

Material and Methods: Seven completely edentulous patients (4 male and 3 females) selected from out-patient clinic of Faculty of Dentistry, Suez Canal University. All patients were completely edentulous for at least 6 months with no previous denture experience with the chief complaint of missing teeth, inability to chew and speak properly. Each patient received mandibular denture and three maxillary dentures with different palatal denture base configuration. The maxillary denture bases were divided into three groups according to their palatal configuration. Group I maxillary denture with functional (customized) palatal contour. Group II maxillary denture with tin foil reproduction of the patient’s palatal rugae on the palatal polished surface. Group III maxillary denture with cast metal denture base. Acoustic analysis was done using computerized software programme. For each patient, 2 measurements were taken (one immediately after insertion and another 3 weeks later). Sound assessment included the /s/, /sh/, /th/ and /d/ sounds. Each subject was asked to pronounce certain words which was evaluated or matched in relation to the normal sound as a percentage (%) for matching of (speaking rate, energy and pitch) to determine the quality of sounds.

Results: There was a highly significant difference between the three groups in favor to reproduced palatal rugae followed by metal palatal one during observation periods.

Conclusion: Based on the results of this study, it could be concluded that, with proper denture construction, the palatine rugae can play an important role in speech pronunciation, as there should be some anatomical landmarks where tongue can recognize and produce best particular sound.

Key Words: Speech – Palatal base configuration – Complete denture.

Introduction

SPEECH is a critical and essential human activity that affects personal communication and self-representation. Together with mechanics and esthetics, speech is a cardinal factor contributing to the ultimate success of a dental prosthesis. The loss of teeth and supporting structures alters the main articulatory cavity and produces a marked effect on this speech pattern [1].

An empiric approach to the phonetic factor in denture construction frequently places the burden for compensating speech depends on the adaptability of the tongue. While it is true that the tongue is very adaptable, functional patterns have become firmly established. However, by customizing palatal contours of a maxillary denture to the tongue, the patient may easily adapt to the definitive denture contour, which in turn shortens or eliminates the adjustment period for the achievement of proper pronunciation [2].

There are persons whose speech is sensitive to the changed relationships between lips, tongue, soft palate, hard palate, alveolar ridge, and teeth and have difficulty accommodating. These patients often require a tactile sense to orient the tongue. The palatal rugae can often serve as cue because the lack of texture on the palatal portion of a complete denture can impede proper articulation. There are some methods to duplicate palatal rugae, one of simplest method is to capture the patient’s palatal rugae by tin foil [3].

Metals and metal alloys used in denture bases display excellent strength-to-volume ratios may be cast in thin sheets maintaining rigidity and fracture resistance. Thinner metallic denture bases decrease interference with phonation and ensure proper palatal contours. Failure to achieve unobtrusive palatal contours may produce noticeable changes in phonation. Metal bases also display desirable dimensional characteristics and may be cast accurately [4].
Little concern has been given to the perfection and optimization of the phonetic quality of denture users. However, insertion of prosthodontic restorations may lead to speech defects. Most of such defects are mild but, nevertheless, can be a source of concern to the patient. For the dental practitioner, there are few guidelines for designing a prosthetic restoration with maximum phonetic success. One of these guidelines involves the palatal configuration of the denture bases.\[5\]

This article studied the effect of different techniques for palatal denture base configuration (functional palatal contour, reproduction of palatal rugae and palatal metal denture base) on Phonetic evaluation of complete denture.

**Material and Methods**

Seven completely edentulous patients (4 males and 3 females) with their age range between 55-65 years were selected from out-patient clinic of Faculty of Dentistry, Suez Canal University. All patients were completely edentulous for at least 6 months with no previous denture experience with the chief complaint of missing teeth, inability to chew and speak properly. All patients were of Angel’s class I maxillo-mandibular relation with available inter-arch space and normal tongue behavior and size. Patients with xerostomia or excessive salivation and those with severe bony undercuts or bony exostosis were excluded. Each patient received mandibular denture and three maxillary dentures with different palatal denture base configuration. The maxillary denture bases were divided into three groups according to their techniques of palatal configurations.

**Group I:** Maxillary denture with functional (customized) palatal contour.

**Group II:** Maxillary denture with tin foil reproduction of the patient’s palatal rugae on the palatal polished surface.

**Group III:** Maxillary denture with metal denture base.

The systematic procedure of complete denture fabrication from primary impression up to the trial denture was followed as usual. After setting up for the artificial teeth for the first group, it is necessary to record the relationships of the teeth to the tissue surfaces of the master cast by making a stone index of the tooth arrangement this jig on the articulator assisted in the arrangement of the artificial acrylic teeth (with the same size, shape and shade) in the same position and the same relationships of the teeth to the tissue surfaces of the duplicated master casts for the other two groups. (Fig. 1-A,B).

At the try-in stage, the trial dentures were evaluated for proper occlusal vertical dimension, anterior teeth arrangement, occlusion, thickness of denture base, retention, stability, aesthetics, phonetics, and comfort.

For the first group: A green-colored indicating material was sprayed on the palatal surface as a contact recording media for recording palatograms to diagnose palatal contour of a denture. The denture was inserted and the patient said “so-so” and opened wide. The contact areas was compared with the general palatogram pattern for an /s/ sound, after removing the denture. An outline of the surface that requires correction with a pencil was drawn. The improperly contoured area of the denture was roughened with a laboratory carbide bur and the acrylic resin was thinned to approximately 2mm in thickness.

Dynamic impression of tongue was done by application of thick mixture of tissue conditioning material (Viscogel, Dentsply, Germany) which was prepared and an adequate amount of the mixture was applied only on the outlined surface. Phonetic evaluation of trial dentures is done by using a method of “Perceptual analysis of articulatory errors and using “Ten stimulus sentences” formulated by Tanaka [5].

The maxillary trial denture base was inserted and the patient was asked to completely read each of the 10 stimulus sentences (Table I), without repeating the same sentence twice, and continue doing so for about 5 minutes at a rate faster than a normal speaking rate.

The trial denture was removed from the mouth, once initial polymerization occurs, the maxillary trial denture base with the functionally molded tissue conditioner (customized palatal contour) (Fig. 2) was flaked, packed with heat cure acrylic resin, processed, finished and polished as usual.
Table (I): Ten stimulus sentences from Tanaka, H.  

<table>
<thead>
<tr>
<th>Sound</th>
<th>Sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ch/</td>
<td>Chuck is watching butch.</td>
</tr>
<tr>
<td>/j/</td>
<td>Jane enjoyed the fudge.</td>
</tr>
<tr>
<td>/sh/</td>
<td>She is watching the dish.</td>
</tr>
<tr>
<td>/zh/</td>
<td>Measure the garage.</td>
</tr>
<tr>
<td>/s/</td>
<td>She is missing one piece.</td>
</tr>
<tr>
<td>/z/</td>
<td>Zelma is busy.</td>
</tr>
<tr>
<td>/t/</td>
<td>Tom wanted a bite.</td>
</tr>
<tr>
<td>/n/</td>
<td>Ned won many prizes.</td>
</tr>
<tr>
<td>/d/</td>
<td>Did eddy lead?</td>
</tr>
<tr>
<td>/i/</td>
<td>Lee will allow it.</td>
</tr>
</tbody>
</table>

For the second group: Tin foil was cut to the desired shape and adapt it to the rugae area on the master cast. The tin foil pattern was removed from the cast and sealed to the palatal area of the completed waxed-up palatal trial denture base with hot base plate wax (Fig. 3-A,B). The denture was flanked, processed, finished, and polished with heat cure acrylic resin as usual.

Fig. (3-A,B): Tin foil pattern for palatal rugae reproduction.

For the third group: Master cast is duplicated by use of reversible hydrocolloid to produce a refractory cast. A wax pattern for the metal palate is developed on the refractory cast, it was adapted to the palatal region of the cast and extended laterally to cover the prescribed areas of the ridge. The retentive elements (the beads) are added to the areas that will be covered by resin. On completion of the waxing invested with refractory material and then cast with alloy. The casting is recovered, finished, polished, and fitted to the master cast. The denture teeth are positioned by use of the jig and wax contouring is completed. The assembly is flanked for compression molding. After wax elimination, the metal palate is recovered and thoroughly cleaned to eliminate residual baseplate wax. The cast metal palate is affixed to the master cast with a small amount of cyanoacrylate cement. In turn, resin is introduced into the mold space and processed with a water bath. The processed denture is recovered, finished, and polished. Laboratory and clinical remount procedure are accomplished for all dentures before complete denture delivery. (Fig. 4-A,B).

Fig. (4-A,B): Maxillary dentures with palatal rugae and metal palatal plate.

Denture assessment:

Objective assessment involved acoustic analysis using computerized software programme (Speak AP) (Fig. 5) is an audio visual biofeedback system (program for evaluation of speech analysis). It could measure three scores, (speaking rate match, energy match and pitch match) which quantifies the stress mismatch and how close was the intonation variations between the different sound segments of patient recording to that of reference (memorized) American English Pronunciation words. For each patient, 2 measurements were taken for each type of denture (one immediately after insertion and another 3 weeks later). Subjects in the control group were subjected to the same protocol of objective assessment only once. Word accuracy WA (%) was computed as a measure for the speech intelligibility score. Sound assessment included the /s/, /sh/, /th/ and /d/ sounds. Percentages (%) for matching of (speaking rate, energy and pitch) were done. The mean of these parameters were calculated, tabulated and statistically analyzed.
**Results**

Data entry and analyses were performed using statistical software program. The quantitative data were presented as mean and standard deviations. One-way analysis of variance (ANOVA) at 95% confidence level was used to examine variable effects. The test was considered significant when $p \leq 0.05$ and highly significant when $p \leq 0.001$. *t*-test for comparison was used to determine which group means were significantly different.

*Records were made for each patient as follows:* 2 times periods (at insertion and after 3 weeks later) for the three types of maxillary dentures during speaking different words to evaluate the pronunciation of s, sh, th and d sounds. The data obtained the for each type and at each time period were summarized and reported in the form of mean values of percentages (%) for matching of (speaking rate, energy and pitch).

*S sound:* To compare between the effect of palatal configuration of the three types of maxillary denture; the mean percentage of matching values and standard deviations of pronunciation for s sound, were calculated throughout different follow-up periods and tabulated (Table 1 and Fig 6-A). The mean values were $71.7\% \pm 1.53$ and $73.6\% \pm 4.01$ for customized palatal contour (GI), and those for reproduced rugea (GII) were $83.5\% \pm 1.17$ and $83.7\% \pm 1.5$ while those for metal palatal denture (GIII) were $79.1\% \pm 3.2$ and $78\% \pm 3.12$ at insertion and after 3 weeks later respectively.

\[
\begin{array}{c|ccc|cc|cc}
\text{S sound} & \text{GI} & \text{GII} & \text{GIII} & \text{ANOVA} & \text{t-test for comparison} \\
\hline
\text{At insertion} & X \pm SD & X \pm SD & X \pm SD & F & P & P1 (GI & GII) & P2 (GII & GIII) & P3 (GI & GIII) \\
\text{71.7\% \pm 1.53} & 83.5\% \pm 1.17 & 79.1\% \pm 3.2 & 54.76 & 0.000** & 0.000** & 0.005** & 0.002** \\
\text{After 3 weeks} & 73.6\% \pm 4.01 & 83.7\% \pm 1.5 & 78\% \pm 3.12 & 19 & 0.000** & 0.000** & 0.007** & 0.004** \\
\end{array}
\]

$X =$ Mean value.

$SD =$ Standard Deviation.

** = Highly significant ($p \leq 0.001$).

*Sh sound:* The mean percentage of matching values and standard deviations of pronunciation for Sh sound, were calculated throughout different follow-up periods and tabulated (Table 2 and Fig 6-B). The mean values were $71.2\% \pm 0.8$ and $72.2\% \pm 1.22$ for customized palatal contour (GI), and those for reproduced rugea (GII) were $85.5\% \pm 1.7$ and $86.7\% \pm 1.46$ while those for metal palatal denture (GIII) were $82.2\% \pm 1.3$ and $83.1\% \pm 1.82$ at insertion and after 3 weeks later respectively.

*For S & Sh sounds:* There was a highly significant difference between the three groups in favor to reproduced palatal rugea followed by metal palatal one during observation periods.
Table (3): Mean percentage of matching values and standard deviations for Th sound between different groups in the follow-up periods.

<table>
<thead>
<tr>
<th>Th sound</th>
<th>GI</th>
<th>GII</th>
<th>GIII</th>
<th>ANOVA</th>
<th>t-test for comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X±SD</td>
<td>X±SD</td>
<td>X±SD</td>
<td>F</td>
<td>P</td>
</tr>
<tr>
<td>At insertion</td>
<td>84.2%±0.56</td>
<td>87.8%±1.44</td>
<td>85.8%±2.04</td>
<td>10.5</td>
<td>0.0009**</td>
</tr>
<tr>
<td>After 3 weeks</td>
<td>85.1%±0.78</td>
<td>88.8%±1.24</td>
<td>87.7%±0.76</td>
<td>28.24</td>
<td>0.0000**</td>
</tr>
</tbody>
</table>

** = Highly significant (p≤0.001).

Th sound: The mean percentage of matching values and standard deviations of pronunciation for Th sound, were calculated throughout different follow-up periods and tabulated (Table 3 and Fig. 7-A). The mean values were 84.2% ±0.56 and 85.1% ±0.78 for customized palatal contour (GI), and those for reproduced rugea (GII) were 87.8%±1.44 and 88.8%±1.24 while those for metal palatal denture (GIII) were 85.8% ±2.04 and 87.7%±0.76 at insertion and after 3 weeks later respectively.

There was a highly significant difference between the three groups in favor to reproduced palatal rugea followed by metal palatal one. There was a significant difference (p-value ≤0.05) between GII & GIII. During observation periods, and significant difference between GI & GIII at insertion.
**D sound:** The mean percentage of matching values and standard deviations of pronunciation for D sound, were calculated throughout different follow-up periods and tabulated (Table 4 and Fig. 7-B.) The mean values were 79.4% ± 1.35 and 83.5% ± 1.22 for customized palatal contour (GI), and those for reproduced rugea (GII) were 82% ± 1.25 and 83.6% ± 1.07 while those for metal palatal denture (GIII) were 81.6% ± 1.1 and 83.1% ± 1.1 at insertion and after 3 weeks later respectively. There was a significant difference between the three groups in favor to reproduced palatal rugea followed by metal palatal one at insertion and non significant difference between the three groups after 3 weeks.

Table (4): Mean percentage of matching values and standard deviations for D sound between different groups in the follow-up periods.

<table>
<thead>
<tr>
<th></th>
<th>GI</th>
<th>GII</th>
<th>GIII</th>
<th>ANOVA</th>
<th>t-test for comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X±SD</td>
<td>X±SD</td>
<td>X±SD</td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>At insertion</td>
<td>79.4%±1.35</td>
<td>82.9%±12.5</td>
<td>81.6%±1.3</td>
<td>9.54</td>
<td>0.001 **</td>
</tr>
<tr>
<td>After 3 weeks</td>
<td>83.5%±1.22</td>
<td>83.6%±1.07</td>
<td>83.1%±1.1</td>
<td>0.453</td>
<td>0.642</td>
</tr>
</tbody>
</table>

*X* = Mean value.  
*SD* = Standard deviation.  
** = Highly significant (p≤0.001).

![Fig. (7-A,B): Bar charts for mean percentage of matching values for th & D sounds.](image)

**Discussion**

Speech production has a significant effect on patients’ general satisfaction with the dentures [6,7].

Different studies 8-10 revealed that the quality of speech production increases after some period of habituation to dental prostheses. The functional quality (retention, support, stability) of the removable dental prostheses is the main recondition for good sound pronunciation [10].

Wearing dental prostheses that modify oral cavity geometry creates a structural perturbation and the concave shape of the palatal vaults of maxillary complete dentures which may disturb the air flow for speech pronunciation causing misarticulation which may impact speech production. This is of clinical significance for patients wearing dentures, spectral analysis demonstrated greater speech distortion in patients with complete dentures that had an increased thickness. Ichikawa et al., [13] reported that the duration of the consonant “s” was increased when the palatal morphology of dentures was altered [11-13].

Differences in palatal morphology may create a differential response to changes in the oral cavity
geometry created by maxillary prostheses. Therefore, when investigating the impact of dental prostheses on speech, it is wise to consider the role of both palatal morphology and gender [14]. Men and women have different speech sound amplification, because of their different oral cavity volume [15].

In this study, conventional technique of upper complete denture not included as a group of research as there is no control of palatal geometry specially rugae area that can affect voice pronunciation quality however, the studied three techniques of palatal base configuration had introduced to improve conventional denture speech defects.

The palatine rugae play an important role in speech production quality. Some persons whose speech is sensitive to the changed relationship with the denture. They require a tactile sense to orient the tongue. Lack of texture on the palatal portion of complete denture can impede proper articulation, as there should be some anatomical landmarks where tongue can recognize and produce best particular sound [3].

When the tongue doesn’t find the rugae it might press forward until it find structure with which it can relate profitably, this might be the teeth so, some letters such Th, and D might be poorly said [16].

Once teeth are correctly positioned at the correct occlusal vertical dimension and on a proper occlusal plane, the palatal contour of a maxillary complete denture should be evaluated for speech intelligibility. A palatogram is a simple and useful diagnostic tool for phonetic evaluation of a maxillary complete denture patient, and functions by representing the records of contact area between the palate and the tongue upon pronunciation of sounds by dynamic impression of the tongue with tissue conditioner, to reproduce the customized palatal contours of a maxillary complete denture as the contact areas for certain sounds are individually determined, there by customizing the palatal contour of a maxillary complete denture, the patient easily gets adapted to definitive denture contour and shows marked improvement in speech [17,18].

Metals and metal alloys used in denture bases casted in thin sheets. Thinner metallic denture bases ensure better adaptation, decrease interference with phonation and ensure proper palatal contours to be unobtrusive for the harmonious relationship to be achieved between the denture and the tongue, which is “the most powerful dynamic articulator” which may lead to uninterrupted speech [4].

On the other hand, sound production depends mainly on resonation, because it is accomplished by alterations in the shape/character of the oral cavity as a resonating chamber and the proper palatal thickness and contour. So, the tongue space was sufficient to allow the tongue to attain the different positions and heights necessary for production of normal sounds [11].

Many different factors, such as the patient turnover at a clinic, the adequacy of the personnel, and the limits of monetary resources, may affect the selection of data acquisition devices and acoustic analysis programs used in a voice clinic. Under these variable circumstances, with respect to the general and important obligations to decrease an environmental, equipmental, intersubject, and intrasubject effects on analysis quality, each laboratory may evaluate their findings according to their own normal data set and report their findings in a similar way [19].

In spite of listener-related and other potential biases, many researchers have tried to correlate the outcome of acoustic-phonetic measures to vocal quality ratings as a ratio. The replacement of analog recording systems with digital recording systems, the availability of automated analysis algorithms, and the non-invasiveness of acoustic measures, combined with the fact that acoustic parameters provide easy quantification of, have led to considerable interest in clinical voice quality measurement using acoustic analysis techniques [20].

Computer-based technique for the objective evaluation of speech intelligibility has long been introduced as a diagnostic tool in adult patients who suffer from neurologic diseases and in children with cleft lip and palate. The method has recently been evaluated for the automated analysis of edentulous patients and patients with complete dentures [21,22].

In consultation with speech therapist and broadcasting engineers they recommended to use speech analysis program for measuring voice pronunciation quality matching to standard normal sounds and we found (SPEAKAP) program which provides three scores which quantify different metrics useful for evaluating the quality of certain words pronunciation compared to same computed memorized words. All scores were in the range 0 to 100% varying from poor to excellent value.

Speech pronunciation improvement with foil technique followed by cast metal technique as related to results might attributed to modifying
the anterior palatal surface to mimic anatomical structures such as incisive papilla and/or rugae in a thinner sections as compared to customize palatal contour. However such structural changes to the prosthesis can only be planned and judged in close collaboration with a qualified speech Therapist [23].

**Conclusion:**

Based on the results of this study, it could be concluded that, with proper denture construction, the palatine rugae plays an important role in speech. As there should be some anatomical landmarks where tongue can recognize and produce best particular sound.

**References**


