Effect of Palatine Rugae on Phonetic Adaptation in Complete Dentures
(Based on the Palatogram Similarity of the Indonesian Linguo-Palatal Consonant)

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Abstract
Phonetic disturbances, or unclear pronunciation,are often found in patients after insertion of a maxillary complete denture. These disturbances can be assessed using a palatogram of the Indonesian linguo-palatal consonant. One method that is often used to improve phonetic adaptation is duplication of the palatine rugae on the maxillary complete denture base. Palatine rugae functioned as tongue placement guidance on the anterior palate to producecorrect articulation of the linguo-palatal consonant sound, especially the letters 't' and 'd.' The purpose of this study was to evaluate palatine rugaeduplicationon maxillary complete denture bases that mightaffect phonetic adaptation. Respondents were 20 wearers of maxillary complete dentures: 10 of the respondents wore maxillary complete dentures with palatine rugae, and 10 of the respondents wore maxillary complete dentures without palatine rugae. Assessment was done using palatogram 't' and 'd' pronunciation, and the similarities with Indonesian palatogram's gold standard were evaluated. This study used the crossover method, and the factors considered regarding the effect of rugae on phonetic adaptation were duration of denture wearing, age, and gender. The study found that it took one week to achieve phonetic adaptation of maxillary complete dentures with palatine rugae. The mean scores of good 't' and 'd' pronunciationwere 60.15 and 69.65 with standard deviations of 3.31 and 3.79, respectively. Conclusion: Maxillary complete dentures with palatine rugae shortens phonetic adaptation.

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Introduction

Palatine rugae could facilitate speech in linguo-palatal consonant pronunciation. In this sound group formation, the palatine rugae comes into contact with and guides the tip of the tongue to produce linguo-palatal pronunciation. When the palatine rugae and hard palate are covered by a denture base, proprioceptive changes occur.[1] Therefore, after insertion of a maxillary complete denture, patients usually suffer phonetic disturbances and unclear pronunciation.[2]

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Phonetic disturbances are actually temporary, as patients adapt well to their complete dentures in a few weeks. This disturbance occurs due to adaptation to a new tongue position, a new inter occlusal relationship, and a new teeth arrangement orientation.[2] Zarb *et al.* stated that it took two to four weeks in general to achieve phonetic adaptation in new denture wearers.[3] According to Falatehan *et al.* speech function could be achieved well after two weeks of denture insertion.

This result showed similarities between palatograms result of the subjects with the gold standard palatograms of the Indonesian linguo-palatal.[4] Meanwhile, a study by Li *et al.* stated that denture wearers could adapt well in one week by duplicating palatine rugae on the denture base and reducing base thickness.[5]

The phonetic adaptation process is influenced by several factors, including patient's previous denture-wearing experience, age, and gender.[4] Generally, it is easier for females to adapt phonetically to new dentures because females speak around 20,000 words per day on average, while males speak only 7,000 words per day on average.[4,6,7]

According to Adaki and Meshram, to facilitate phonetic adaptation, duplicating the palatine rugae in the palatal part of the denture base as a guidance for tongue position on the palate could facilitate linguo-palatal consonant speech, especially the letters 't' and 'd,' in wearers of maxillary complete dentures.[8-10]

To diagnose phonetic disturbances, an examination using a palatogram can be done. A palatogramis used to evaluate phonetics and could be used as a diagnostic tool in treating phonetic problems in linguo-palatal consonant pronunciation. In this study, the linguo-palatal consonants used were the letters 't' and 'd'. These letters were considered linguo alveolar, or linguo palatal, sounds—the sound produced by contacting the tip of the tongue with the anterior palate or lingual side of the anterior teeth.

The arrangement of the maxillary anterior teeth that were too lingual would result in the letter 't' sounding like the letter 'd.' On the other hand, the arrangement of the maxillary anterior teeth that were too labial would result in the letter 'd' sounding like the letter 't.'[10]

The gold standard of the Indonesian palatogram for linguo-palatal consonant pronunciation was found by Andries *et al*.[11] This gold standard for the palatogram was used as a measurement tool in evaluating phonetic disturbances because the author worked with Indonesian-speaking respondents.

This study was conducted to determine the role of rugae palatina on the complete denture base in assisting phonetic adaptation, especially in the pronunciation of the letters 't' and 'd,' which also have not been studied in Indonesian pronunciation. In the pronunciation of the letters 't' and 'd,' the tongue touches the anterior portion of the palatal base, which is the location of the palatine rugae.

Methods

This study was a cross over clinical trial with consecutive sampling method. Subject determination for each group was done by random allocation using a coin. There were two subject groups: Group I was subjects who wear maxillary complete dentures with palatine rugae, while Group II was subjects who wear maxillary complete dentures without palatine rugae. The subject size in each group were 10 persons.

Inclusion critera for the subjects were as follows: being patients of dental students and prosthodontic residents in the Dental Teaching Hospital, Faculty of Dentistry, Universitas Indonesia (RSGMP FKG UI); having normal jaw relation; not having any mental disturbances that could affect treatment and speech; not having speech problems; not having neuro muscular abnormalities that interfere speech; and never having used complete dentures before or being in the process of making a complete denture. Patients who did not want to participate in this study were excluded from the study.

Data collection began with explaining the study to the participants and obtaining the subjects' informed consent. Subjects in Group I in period I were given maxillary complete dentures with palatine rugae fabrication in the anterior palate base with 1.5-2.5mm thickness. Meanwhile subjects in Group II in period I were given maxillary complete dentures without palatine rugae fabrication in the anterior palate base with 1.5-2.5mm.

All dentures were evaluated using Pressure Indicator Paste (PIP) application, which involved using a brush to spread 3 grams of fletcher powder and 5 ml of olive oil evenly and in the same direction from anterior to posterior on the denture palatal base. The denture was then inserted into the mouth, and the subject was instructed to pronounce the letters 't' and 'd.' Next, the denture was removed carefully without touching the palatal base so that the palatogram result was not brushed by a finger. Lemon juice was used to clean the PIP on the subjects' mouth.

Palatogram results were photographed perpendicularly from a distance of 20 cm using a 12 MP digital camera so that the result could be processed using the Adobe Photoshop program to analyze the data of each subject. Photos were taken upon the first insertion of dentures and seven days after insertion (control).[4,10,12,13]

The palatogram was analyzed by dividing it into 24 squares (Figure 1 and 3), and the area where maximum contact occurred (area where

PIP was erased) was counted. In the study of the golden standard palatogram of the Indonesian language, it was set that the cutting points for the palatogram were 100-80% black, 79-60% grey, 59-40% dots, 39-20% squares, and 19-0% white. Then, the maximum contact distribution of the tongue on the denture base was compared to the golden standard palatogram of the Indonesian language (Figure 2 and 4).[11]
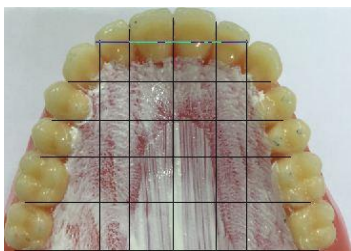

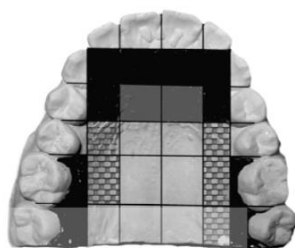**Figure 1.** Palatogramresult of pronunciation

Figure 2. Apico-palatal consonant 't' letter 't' in the study(study by Andries[12])
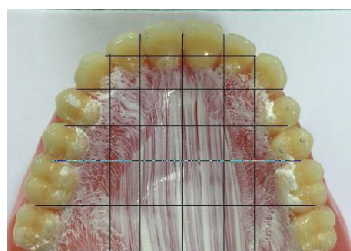

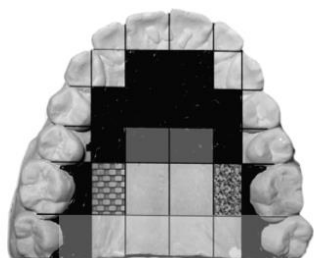**Figure 3**. Palatogram of letter 'd'

Figure 4. Apico-palatal consonant 'd' study (study by Andries[12])

After pictures had been taken at control periods, the process continued to the wash out stage in Groups I and II in which subjects were instructed not to use dentures for two to three days. After the wash out stage, the process was continued to period II. In Group I, the palatine rugae were removed, while in Group II,the palatine rugae were created using the putty index.

To create the palatine rugae in the denture base, impressions of the palatine rugae pattern of each subject were taken from working models using putty. Complete denture base thickness was reduced atthe anterior palate region by 1 mm, and auto-polymerizing acrylic resin was applied. Next, the putty was pressed onacrylic resin until it set. Excessive palatine rugae area was removed and lightly polished.

Afterwards, PIP was applied asin theprevious procedure;pronunciation of the letters 't' and 'd' was done; and photographs were taken at insertion and seven days after insertion. The result was assessed using Adobe Photoshop.

Data from the palatogram was assessed with statistical analysis. Data analysis was done using univariate analysis to assess normality, data distribution, and mean value. Then, bivariate analysis was done to assess palatine rugae effect on phonetic adaptation using an independent t-test. To assess the effect of the palatine rugae each confounding factor, an independent t-test was also used.

Result

Amongst the 20 subjects (9 women and 11 men), 9 of them were less than 60 years old while the other 11 subjects were 60 years old or older. To know whether the data had a normal distribution, a normality test was done. The data obtained had a sample size of less than 50, so the normality test used was Saphiro-Wilk. The result of the Saphiro-Wilk normality test in the letters 't' and 'd' were p values of 0.451 and 0.983, respectively. Because p value > 0.05 it could be concluded that data distribution was normal. Afterwards, an independent t-test was done to assess the significance of the difference between the two groups (with palatine rugae and without palatine rugae).

From the independent t-test in sig value (2-tailed), a significance value of 0.000 was obtained ($p < 0.05$) (Table 1). Therefore, it could be concluded that there was a significant difference in palatogram values between the

group with palatine rugae and the group without palatine rugae in pronunciation of both letters 't' and 'd.'

Table 1. Analysis result of palatogram value between subjects using dentures with palatine rugae and without palatine rugae on the seventh day after insertion.

	Rugae		Without Rugae		p value
	Mean	Standard Deviation	Mean	Standard Deviation	
Letter 't'	60.15	3.31	44.60	2.87	0.000
Letter 'd'	69.65	3.79	53.80	4.58	0.000

Bivariate analysis was also done to analyze thedifferences in the phonetic adaptation of the maxillary complete denture base with palatine rugae in pronunciation of the letters 't' and 'd' based on age groups (<60 years old and ≥60 years old) with an independent t-test.

Based on the palatogram value test with palatine rugae in pronunciation of the letter 't' the significance value obtained was 0.053 (p > 0.05) (Table 2). This result showed that there was no significant difference in pronunciation of the letter 't' in the young age group (<60 years old) and the older age group (≥ 60 tahun).

Table 2. Analysis result of palatogram value with palatine rugae in letter 't' and 'd' pronunciation based on age groups.

Age	Mean	Standard Deviation	p
Letter't'			
< 60 years old	61.78	2.33	0.053
≥ 60 years old	58.82	3.48	0.053
Letter'd'			
< 60 years old	71.33	2.87	0.071
≥ 60 years old	68.27	4.00	0.071

Meanwhile, the palatogram with palatine rugae value test in pronunciation of the letter 'd' resulted in a significance value of 0.071 (p > 0,05) (Table 2). This meant that there was no significant difference between pronunciation of the letter 'd' in the young age group (<60 years

old) and the older age group (≥ 60 tahun). So, it could be concluded that there was no significant difference in pronunciation of the letters 't' and 'd' in both the young and older age groups.

Bivariate analysis was then done to analyze thedifferences of phonetic adaptation in maxillary complete denture base with palatine rugae in pronunciation of the letters 't' and 'd' based on gender with an independent t-test.

Based on the palatogram with palatine rugae value test in pronunciation of the letter 't' the significance value was 0.933 (p > 0,05) (Table 3). This result showed there was no significant difference in pronunciation of the letter 't' in females and males.

Table 3. Analysis result of palatogram with palatine rugae value in letter 't' and 'd' pronunciation based on gender.

Age	Mean	Standard Deviation	p
Letter't'			
Women	60.22	2.81	0.933
Men	60.09	3.80	0.933
Letter'd'			
Women	69.89	3.18	0.806
Men	69.45	4.36	0.806

Meanwhile, the palatogram with palatine rugae value test in pronunciation of the letter 'd' resulted in a significance value of 0.806 (p > 0,05) (Table 3). This means that there was no significant difference in pronunciation of the letter 'd' between females and males.

Therefore, it could be concluded that there was no significant difference in pronunciation of the letters 't' and 'd' in females and males.

Discussion

Patients who have lost all their teeth and their supporting structures often experience changes in oral cavities, thus causing significant disturbances in speech patterns. These phonetic disturbances could be treated with complete denture fabrication. However, fabrication of complete dentures often requires tongue adaptation from a previous edentulous condition to a new condition with dentures. The change in

this condition causes temporary speech function due to palate coverage by the denture base.

When the palate is covered, changes in the air flow through the oral cavity cause changes in the pronunciation of letters. These changes in air flow are controlled by the tongue, lips, and palate dynamic structures. Therefore, wearing complete dentures changesthe tongue contact orientation on the palate.[14] According to Vijayaraghavan *et al.* one method to reduce speech disturbances is to create a palatine rugae contour in the palatal part of complete dentures, as the lack of texture condition affects correct articulation.[15] Palmer stated that non-anatomical papilla formation in the posterior part of the incisive papilla on the palatal surface of complete dentures could help tongue identification. The non-anatomical papilla was palatine rugae with an elongated transverse shape.[16]

In this study, subjects were given maxillary complete dentures with palatine rugae. Palatine rugae fabrication was done to mimic each patient's palate condition as if the palatal base was the patient's own palate. It was hoped that the complete dentures worn by the patients would be similar to the palate shape and teeth when the patient still had teeth so that the adaptation periods could be shorter.

Next, phonetic adaptation could be assessed by comparing patients' palatograms with the golden standard of the Indonesian language palatogram. Though five pairs of linguo-palatal consonants exist, assessment was done only on pronunciation of the letters 't' and 'd' because these letters were the only ones that involve tongue movement to the anterior palate.

Palatogram data collection was done on the day of insertion and seven days after insertion. This was done based on a study by Li *et al.* that fabricated palatine rugae on a complete denture base, which the patients were able to adapt to in one week after denture insertion.[5]

This study used a cross over design. This design was selected because the patients themselves were used as controls, as the contact pattern of one individual was not the same as the others. Therefore, anatomical structures such as palate shape, jaws, and tongue size were the same, and those variables could be controlled. This was important because the palate shape and size of tongue affected phonetic adaptation.

In this method, two treatments were given, and one of those treatments served as a control. Between those two treatments, subjects were given a two- to three-week wash out period to remove adaptation that occurred in the first treatment. The purpose of this wash out period was to prevent bias. A study by Martins *et al* used the cross-over method and a wash out period of 15 days.[17] Meanwhile, a study by Paleari *et al* did not use a wash out period.[18] Based on those two studies, there was no golden standard for the length of the wash out period, so the author of the current study assumed that a wash out period of two to three days could remove any previous adaptation processes.

It could be concluded that there was significant difference between the palatogram value of the denture with the palatine rugae and the palatogram value of the denture without the palatine rugaefor both letters 't' and 'd' seven days after insertion. Based on this analysis, it could be concluded that the palatine rugae on the maxillary complete denture base could increase phonetic adaptation in pronunciation of the letters 't' and 'd.'

Patients wearing maxillary complete dentures with palatine rugae adapt faster compared to patients wearing maxillary complete dentures without palatine rugae in a one-week period. This result corresponded with the study by Li *et al*.[5] Vijayaraghavan *et al.* stated that palatine rugae fabrication in new and old dentures might reduce speech problems.[15] Meshram and Adaki also stated that a prosthesis with palatine rugae contour showed better adaptation compared to conventional prosthesis in acoustic analysis.[19]

Therefore, it could be concluded that patient's phonetic adaptation could improve with creation of the palatine rugae, and the needed adaptation time was also shorter. Based on this study, it was known that age did not affect phonetic adaptation in denture-wearing patients. This was different from the study by Falatehan *et al*, which stated that younger patients were easier to adapt compared to older patients.[4] This study also found that there was no significant difference between pronunciation of the letters 't' and 'd' in females and males. This corresponded with a previous study that found there was no significant difference between females and males wearing dentures with palatine rugae in the Japanese and Indian children population.[20]

The weakness of this study was that the subjects were only divided into two categories: <60 years old and ≥60 years old. Thus, future studies should involve subjects across a larger age range and a shorter age span.

This study also did not consider anatomical structure classifications that affect speech function such as palate height, shape of hard and soft palate, and jaw relation. This was because those anatomical structures did not experience changes, as the structures originated from the same subjects. The golden standard palatogram of the Indonesian language could only be used to analyze disturbance in the pronunciation of some linguo-palatal consonants. Thus, further study shouldbe conducted to assess other linguo-palatal consonants.

Conclusion

Fabrication of palatine rugae on maxillary complete denture bases could increase phonetic adaptation in pronunciation ofthe letters 't' and 'd' with shorter phonetic adaptation time needed. Age and gender do not influence phonetic adaptation in patients wearing maxillary complete dentures with palatine rugae fabrication in pronunciation of the letters 't' and 'd.'

Thus, it was suggested that palatine rugae be made in the maxillary complete denture base at the anterior palate region to facilitate phonetic adaptation of wearers of complete denture.

Further study could divide subjects into more age groups based on the Indonesian Ministry of Health. Moreover, a study could be done about phonetic adaptation related to classifications of anatomic structures that affect speech function as other confounding factors. Further study on other linguo-palatal consonants could also be done.

Acknowledgement

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