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RESEARCH ARTICLE

THE EFFECT OF INCORPORATION OF POSTERIOR PALATAL SEAL AND RUGAE IN COMPLETE DENTURE ON PERCEPTUAL AND ACOUSTIC DIMENSIONS OF DENTURE WEARER'S SPEECH

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ABSTRACT

Context: If the dentures satisfy the requirement of function and esthetics, Patients usually maintain acceptable speech. However, few patients with complete dentures face difficulty and their speech becomes a matter of concern. Recording the posterior palatal seal area and palatal rugae provides a psychological satisfaction in terms of good fit and good phonetics.

Aim: To compare the perceptual and acoustic characteristics of velar sounds like/ka/,/ga/ and stop consonanats like /ta/, /da/ in an edentulous patient, with and without Posterior palatal seal and palatal rugae area recorded in the denture of complete denture wearers.

Materials and Methods: The study group was then divided into two groups. In the first fifteen patients' dentures only the posterior palatal seal was incorporated using mouth temperature wax. The speech language pathologist again recorded speech samples both perceptually and acoustically. Then the rugae were incorporated into their dentures and again the speech analysis was carried out. For the remaining fifteen patients' dentures, only the rugae were incorporated using modelling wax. The speech language pathologist recorded speech samples both perceptually and acoustically for these patients. Then the posterior palatal seal was incorporated into their dentures and again the speech analysis was carried out. In the entire appointments patient were evaluated for the same speech and velar stop consonant monosyllable /ka/ and /ga/ mainly, along with letters like t, d.

Results: Acoustic analysis showed a significant relationship between the acoustic characteristics of velar sounds and stop consonant with the posterior palatal seal and rugae area record in the denture.

Conclusions and clinical Implications: The study implies that Prosthodontist and Speech Language Pathologist can work together as a team for more accurate fabrication of the denture.

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INTRODUCTION

Speech is an unique, complex, dynamic motor activity through which we express our thoughts and respond to control our environment. (McDowell, 1936) It is one of the most powerful tool possessed by human species, and degree to which we employ it effectively contributes to character and quality of our life. (McDowell, 1936) The unique complexity of the oral cavity and adjacent tissues present continual challenges to the Prosthodontist, among which speech problem is a major concern. (McDowell, 1936) Changes in the oral cavity resulting from loss of teeth and alterations caused by dental prostheses could affect speech articulation. (Sears, 1949) When the oral environmental conditions suddenly change, disturbance in speech prevails. (Sears, 1949) Thus, speech rehabilitation for these edentulous patients becomes an onerous task for the Prosthodontist. (Sears, 1949) The speaking sounds are produced by the contact of tongue with some portion of the lips, palate and teeth. (McDowell, 1936) These contact areas are either replaced or covered by complete denture. (McDowell, 1936) Failure to contour the palate to accommodate normal tongue contact usually results in poor speech. (McDowell, 1936) Patients usually maintain acceptable speech if the denture satisfy the requirement of function and esthetics. (Sears, 1949) However, some patients wearing complete dentures encounter difficulty. (Wright *et al*.,

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1949) If posterior palatal seal area is not incorporated well in the denture, there exists a gap between the posterior most part of the denture and the soft palate as there is no contact between the two during the functional movement of the soft palate. (Meyer M Silverman, 1953; Van Riper, 1954; YlIpo, 1955) Also, the masking of palatal rugae, when it is covered with denture base have been related to articulatory insufficiency, because they act as tactile guide posts. (Wright *et al*., 1949; Meyer M Silverman, 1953; Van Riper, 1954; YlIpo, 1955) Hence, these oral landmarks are important as far as phonetics in denture construction is involved, (Ylipo, 1955; MilIer and Nicely, 1955; Martone, 1957; Kessler, 1957; Martone and Edwards, 1961; AlIen, 1958; Ailen, 1958). This study emphasizes on the Prosthodontist's contribution as a team member working with speech language pathologist in the appropriate fabrication of denture by evaluating the patient speech.

MATERIALS AND METHODS

The subjects in this study were the patients visiting the Department of Prosthodontics, K.V.G. Dental Collage and Hospital, Sullia and for the purpose of the study, 30 completely edentulous patients in the age group of 45 to 55 years were selected randomly. The inclusion criteria were completely edentulous patients, first time denture wearers, with acceptable articulation of speech and native speakers of Kannada or Malyalam language who can read their languages. The exclusion criteria was pathological changes in the oral form and structure, if any. Patients having speech defects are associated with changes in oral form and structure (cleft lip and palate, glossectomy case, neuromuscular problems, oral pathological lesions). Patients already having some discrepancy in speech which might hinder in comparison. Thirty completely edentulous patients were selected for the study. Subjects were informed about instruments and procedures to be performed and consent was obtained. Complete dentures were fabricated without the incorporation of posterior palatal seal and palatal rugae. After wearing the denture, the patients were taken to the speech language pathologist to record and analyze the speech samples both perceptually and acoustically (Fig.1). The study subject where then divided into two groups and the first fifteen patients' dentures were incorporated with the posterior palatal seal, only using mouth temperature wax melted on the digital wax melter. The speech language pathologist again recorded and analyzed speech samples both perceptually and acoustically. Then the rugae was incorporated into their dentures and again the speech analysis was carried out (Fig 2,3). For the remaining fifteen patients dentures, only the rugae was incorporated using modelling wax. The speech language pathologist recorded and analyzed speech samples both perceptually and acoustically for these patients. Then the posterior palatal seal was incorporated into their dentures and again the speech analysis was carried out (Fig 2,3). For recording rugae area in denture; addition silicon impression of rugae was made and then modeling wax was flown on to the imprint of rugae. After hardening, it was taken out and positioned on to the anterior palatal portion of their respective maxillary dentures and sealed to merge with remaining palatal portion of the denture (Fig.4). Posterior palatal seal area was recorded by fluid wax technique on to the posterior most part of the processed and polished denture (at the time of fit in). Fluid wax technique utilized a special mouth temperature wax (MP Sai, Mumbai) which is painted on to the posterior most intaglio surface of the denture, between the two vibrating lines transferred to the denture using indelible pencil.

Articulation test

For perceptual analysis the articulation test was done and the material contained in word list from Kannada Articulation Test (Babu & Rathna, 1985) and Malayalam Articulation Test (Maya, 1990). The samples were collected by qualified speech language pathologists and these samples were subjected to perceptual analysis for speech intelligibility rating. Linguovelar (velar) sounds like /ka/ and /ga/ which is affected by the extent and seal of the posterior palatal area on the soft palate, were considered. Patient was also asked to speak stop consonants like /pa/, /ga/, /ka/, /ba/, /da/. (Rutter and Martin, 1972; Penniceard, 1981; Schuberth *et al*., 1982; Klein, 1984; Riski and Delong, 1984)

Data collection for acoustic analysis

One subject at a time was examined and the reading samples of that subject were recorded in four conditions. (Parush and Ostry, 1986; Michi *et al*., 1986; Parsons, 1987)

Condition 1: subjects were asked to speak the stop consonants like /pa/, /ta/, /da/, /ka/, /ba/, /da/, */ga/* and mainly sounds like /ka/ and /ga/.

Condition 2: subjects were asked to speak the stop consonants again, while subjects were wearing the denture with the incorporation of only posterior palatal seal area in denture and recordings were carried out.

Condition 3: subjects were asked to speak the stop consonants again, while the subjects were wearing the denture with incorporation of only rugae area in denture and recordings were carried out.

Condition 4: subjects were asked to speak the stop consonants again, while the subjects were wearing the denture with incorporation of both posterior palatal seal and rugae area in denture and recordings were carried out.

Data collection for perceptual analysis

One subject at a time was examined and the readings samples of that subject were recorded in four conditions.

Condition 1: The subjects were asked to read the words from the articulation test list for speech intelligibility when he/she is wearing complete denture without the incorporation of posterior palatal seal and rugae and the recording was carried out.

Condition 2: The subjects were asked to read the words from the articulation test list for speech intelligibility when he/she is wearing the complete denture incorporated with only posterior palatal seal and recording was carried out.

Condition 3: The subjects were asked to read the words from the articulation test list for speech intelligibility when he/she is wearing the denture incorporated with only rugae and recordings was carried out.

Condition 4: The patient were asked to read the words from the articulation test list for speech intelligibility" when he/she is wearing the denture with incorporation of posterior palatal seal as well as rugae and recordings were obtained.

Recording for perceptual and acoustic analysis

As the subjects reads the word list, speech output were recorded using PRAAT software, through the microphone

placed at a distance of 1.5 cm away from their mouth at a sampling rate of 16 kHz and stored for further analysis. The total time taken for recording of each subject varied from 15 to 20 minutes, approximately. The study result were analyzed using Wilcoxon Sign Rank test, Kruskal Wallis test and Chi Square test.

RESULTS

With regards to the Perceptual Analysis, there was no difference obtained in speech intelligibility with and without the posterior palatal seal and rugae area recorded in the denture by all the examiners. (Table 1) The results showed that more time was required to produce velar sounds monosyllable /ka/ ga in terms of burst duration and voice onset time, if posterior palatal seal area and rugae was not recorded well as there always exists a gap between the post dam area and the soft palate. Patient had difficulty in speech as the time required for the break in articulation of the tongue and soft palate followed by the vibration of the vocal cord is delayed. This is because the palatal coverage hinders the tactile feedback mechanism to a large extent and therefore limits the ability to properly articulate. (Parsons, 1987) As the palatal coverage hinders the tactile feedback mechanism to a large extent, and therefore limits the ability to properly articulate. (Parsons, 1987) (Table 2) The results were statistically significant ($p< 0.001$) which shows that the dentures with the P.P.S and rugae area record is better in terms of burst duration and voice onset time than that of the denture in which P.P.S and rugae area is not recorded. Without the P.P.S and rugae area record the velar sound is more spread and vice versa. Lesser the spread better is the sound produced. (Graph 1)

Table 1. Intelligibility rating for speech with and without posterior palatal seal area record which was subjective. (1= Good, 2= Satisfactory, 3= Poor)

Stop consonants	With P.P.S. Record	Without P.P.S. Record
'pa/	2	2
'ta/	2	2
/ka/ (velar)	2	2
/ba/	2	2
/da/	2	*2*
/ga/ (velar)	2	2

Table 2. Statistical analysis for Velar Stop consonants in monosyllables

Parameters	With p.p.s. Record	Without p.p.s. Record	Z	P
1. Burst duration (msec)	19.4200	27.3200	-4.782	<0.001 (VHS)
2. Voice onset time (msec)	85.5200	98.0000	-4.782	<0.001 (VHS)
3. Formant frequencies(hertz) :				
a) F1 (hertz)	765.5500	749.8750	-4.782	<0.001 (VHS)
b) F2 (hertz)	1572.4250	1428.9700	-4.782	<0.001 (VHS)
c) F3 (hertz)	2750.2150	2633.9000	-4.782	<0.001 (VMH)
d) F4 (hertz)	3894.4650	3719.2950	-4.782	<0.001 (VHS)

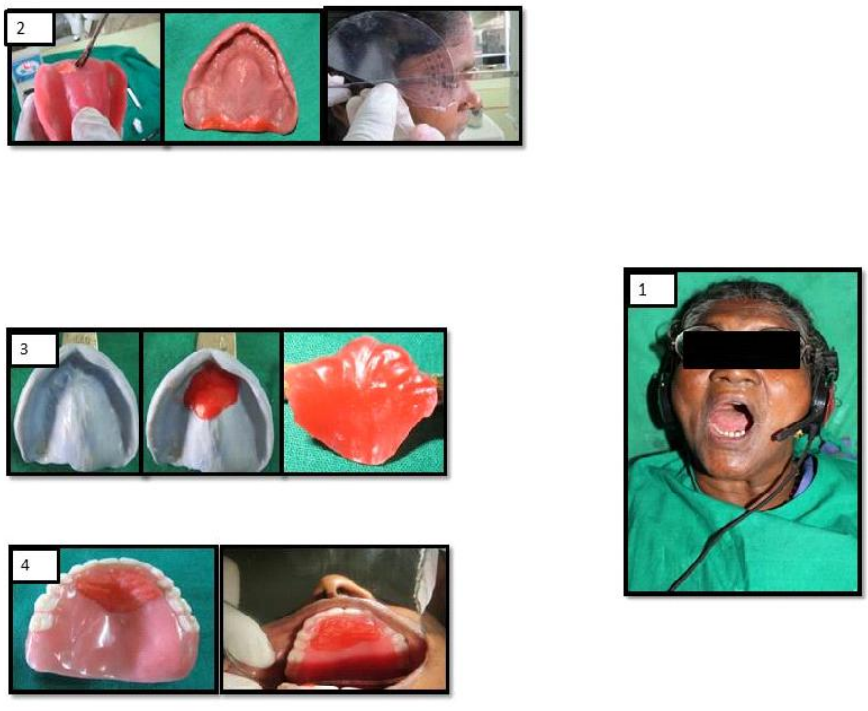

Fig.1. Recording and analyzing speech sample

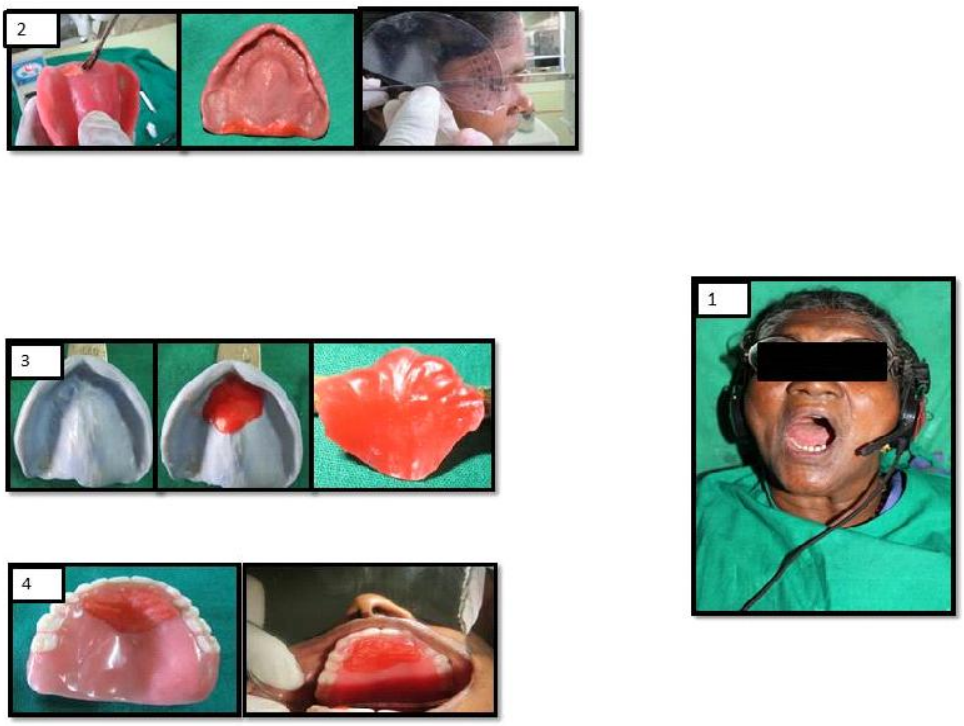

Fig.2. Steps involved in recording Posterior Palatal Seal(PPS) area

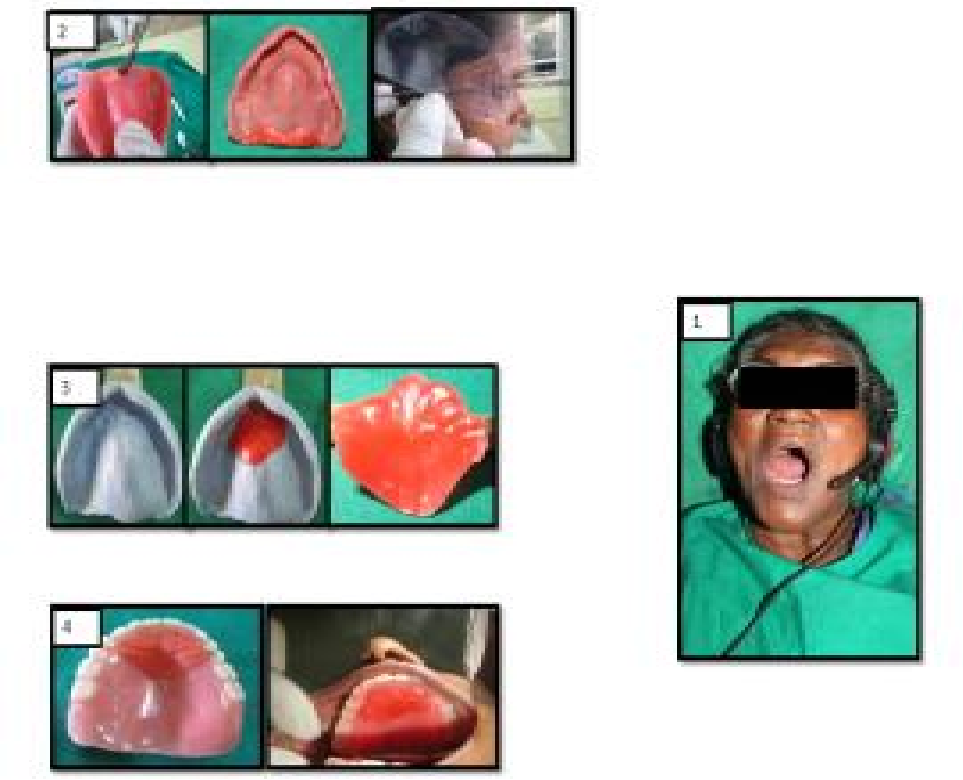

Fig.3. Steps involved in recording rugae area

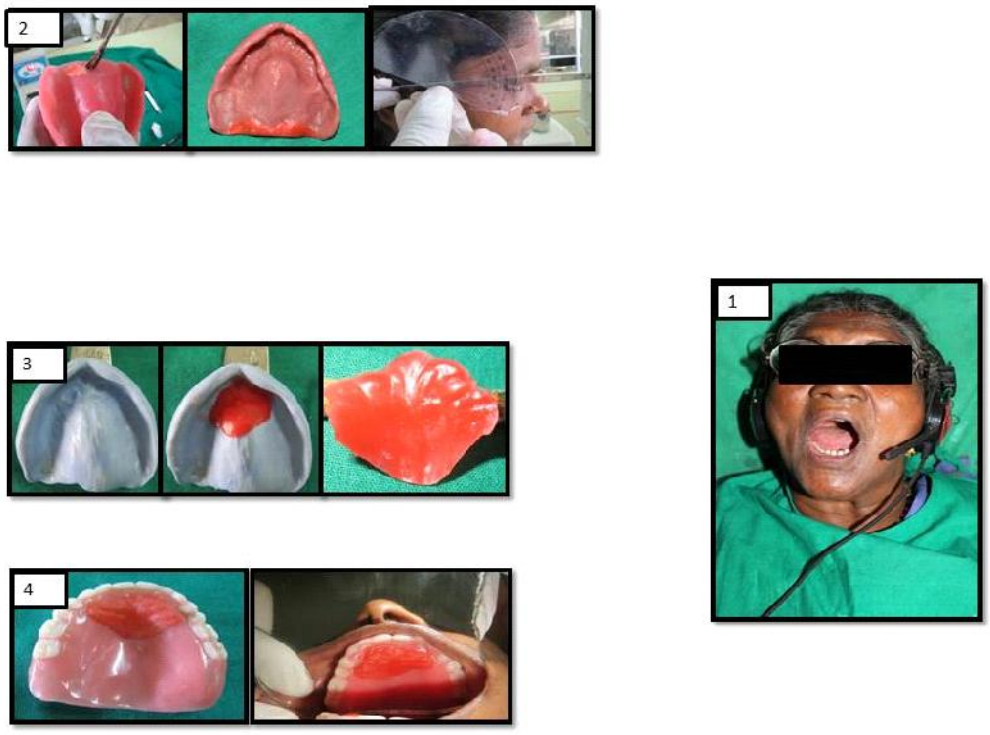

Fig.4. Denture with rugae record

DISCUSSION

In the present investigation, an assessment of the effect of speech intelligibility was carried out and for this purpose, the speech data of the same edentulous patient was analyzed perceptually and acoustically, with and without the incorporation of posterior palatal seal and rugae area in the denture. The acoustic analysis was done for velar stop consonants monosyllable /ka/ and /ga/ using an automated speech recognition system (PRAAT software) that measured speech in terms of burst duration (B.D.), voice onset time (V.O.T.) and formant frequencies (F1, F2, F3, F4). Acoustic analysis is the most useful tool in assessing the phonetics and it's been used in studies related to speech sciences on very wide scale. Summers found that utterencies produced in noise were more intelligible then utterencies produced in quiet. The results of acoustic analysis showed clear and consistent differences in acoustic-phonetic characteristics of the speech produced in quiet versus noisy environments. Moreover, these accounts differences produced reliable effects on intelligibility (Parsons, 1987; Summers *et al*., 1988) For phonetics many factors are responsible like lining mucosa (Meyer M Silverman, 1953), tongue, palate etc. Complete denture prosthesis, with and without the record of posterior palatal seal and rugae area did not show any significant difference in the speech when analyzed perceptually by three different speech pathologist. All the three raters, rated the speech to be satisfactory. As the perceptual analysis method used to assess speech sounds is a subjective method so a total of three trained speech pathologists were chosen to analyze the samples. Multiple-choice tasks by multiple evaluators are considered to be suitable for obtaining reliable result. The study was a single-blinded study as test samples were randomized and none of the examiners knew which sample they were analyzing. Whereas when acoustic analysis was done for velar stop consonant monosyllable /ka/ and /ga/, a very significant result was obtained in terms of burst duration, voice onset time and formant frequencies. Burst Duration is the time required for a noised burst heard immediately after the break in contact of the articulator. This period is usually measured in milliseconds. Voice onset time is the duration of the period of time between the release of a plosive and the beginning of vocal fold vibration. It is usually measured in milliseconds and a Formant frequency as defined by Gunnar Fant is measured as an amplitude peak in the frequency spectrum of the sound. The formant with lowest frequency is called F1 followed by F2, F3, F4 (Summers *et al*., 1988). In the agreement of the present study, an improvement in the intelligibility of patients with an edentulous maxillary arch was stated in studies that used a perceptual rating of speech intelligibility or spectral analysis to assess single distorted sounds. In these studies, the articulation of fricative sounds in particular posed with the problem for the edentulous speakers, which may explain reduced intelligibility. (Parsons, 1987) The maxillary incisors and their positions were found crucial for speech production (Klein, 1984) and there are many studies concerning the size and thickness of complete denture on speech production. Subjective evaluation of the effect of the mandibular prosthesis on the quality of life was done. Studies in this area implicate that the mandibular prosthesis seem to influence masticatory function or stability to a greater extent than does speech production. When comparing the data collected, with and without P.P.S. and rugae area record, and that of only P.P.S. and only rugae for velar stop consonants monosyllable /ka/ and /ga/ it was concluded that in pronunciation for both the stop consonants there was significant difference in the acoustic characteristics. More time

was recorded for the production of velar sounds in terms of burst duration and voice onset time, measured in milliseconds for the denture both without P.P.S. and rugae, and only rugae records and vice versa. Whereas for the formant frequencies, denture without P.P.S. and rugae record and only rugae showed less frequencies at different locations of the vocal tract and vice versa. Minimum being just above the vocal cord and it increased as it proceeded towards the open end of the oral cavity. A possible explanation may be the fact that the complete dentures lack retention and stability because of the lack of adequate seal at the posterior palatal seal area. Hence, macro and micro movement of the mucosal base may interfere with the articulation, reducing the intelligibility of speech. (Parsons, 1987)

Additionally, the palatal coverage itself and its influence on the geometry of the oral cavity are known to be the main factors for reduced speech intelligibility in complete denture wearers. Posterior Palatal seal and rugae area coverage hinders the tactile feedback mechanism to a large extent, and therefore limits the tongue to properly articulate with the soft palate for sound production (Parsons, 1987; Fletcher, 1988). Since every alteration in the oral cavity may cause impairment in the speech production, it is consequently assumed that appropriate record of the posterior palatal seal and rugae would not alter the acoustic characteristics of speech in extended palatal coverage. (Summers, 1988)

Learning points

1. There was a statistical significant difference in Burst duration of speech, showing more spread of velar sounds in terms of milliseconds, without the record of posterior palatal seal with rugae area and only rugae area record,vice versa.(Acoustic reading no. 1 and 4)
2. With the proper record of posterior palatal seal and rugae or only posterior palatal seal area in the denture, voice onset time showed less spread of velar sounds in terms of milliseconds. (Acoustic reading no. 2 and 5)
3. There was a statistical significant difference in formant frequencies of velar sounds, showing more frequencies in terms of Hertz, with the record of posterior palatal seal area with rugae and only P.P.S. vice versa. (Acoustic reading no. 3 and 6)
4. Perceptual analysis (purely subjective) did not show any difference when articulation test was performed by three different qualified speech language pathologist.

Conclusion

Speech is a global parameter for the success of a prosthetic rehabilitation. A computer based, automatic, rater- independent speech is a useful tool to evaluate voice quality in terms of burst duration, voice onset time and formant frequencies. This study implies that Prosthodontist can contribute effectively as a team member, working with Speech Language Pathologist in the appropriate fabrication of the denture, by evaluating the patients speech with respect to posterior palatal seal and rugae area recorded in the intaglio surface of the denture (post-dam area).

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