

Phonetic analysis and maxillary anterior tooth position: a pilot study on preliminary outcomes

Martina Giovannetti, Alessio Casucci, Daniele Casucci, Claudia Mazzitelli, Andrea Borracchini

Abstract

Objectives: This pilot study was carried out to evaluate the effect of different maxillary central incisor positions on the /s/ speech sound in patients wearing maxillary complete dentures.

Materials and methods: The maxillary dentures of six subjects were duplicated. A silicon key was used to fix the position of the central incisors. This procedure enabled the anterior teeth to be moved palatally, or closer to the crest of the alveolar ridge. Subjects were invited to pronounce the Italian word "sasso" eight times with each prosthesis. Data were analyzed using "Multi-Speech" software. The /s/ sound was measured and the fundamental frequency (F0), energy spectrum and Fast Fourier Transform (FFT) determined. Records were statistically analyzed with the Kolmogorov-Smirnoff and Paired t tests ($p < 0,05$). **Results:** No statistically significant differences in terms of the /s/ sound were found in patients wearing suitable or modified complete dentures, as determined by the "Multi Speech" software ($p > 0,05$). Differences were found between males and females in terms of fundamental frequency ($p < 0,05$). Acoustically, when the central incisors were positioned in a more palatal or lingual position, a "whistled" effect was assessed in all subjects. **Discussion:** Although there are several causes of misarticulation in complete denture wearers, both males and females wearing prostheses with a more palatal tooth position have more speaking difficulties as the dentures reduce the oral cavity volume. The 2-dimensional Cartesian coordinates record higher energy levels in low frequencies for men and intermediate frequencies for women. The energy peaks in high frequencies of the female group are heard as a "whistled air effect". **Conclusions:** Within the limitation of this pilot study, the position of the maxillary central incisors is an important factor in determining phonetics. In the case of a more palatal tooth position, acoustic changes may be observed, which result in patient's stress load over time. **Clinical significance:** Clinicians should take care in determining the correct central incisor position in complete dentures in order to avoid any undesirable phonetic distortions to patients. Complete dentures with anterior teeth set too far palatally present many problems, including aesthetic and phonetic alterations, sometimes resulting in a "whistle". **Short title:** Phonetic analysis in complete denture wearing patients.

Key words: complete denture, anterior tooth position, phonetic disturbances, oral cavity volume.

Martina Giovannetti, DDS, PhD student, Department of Fixed Prosthodontics and Dental Materials, University of Siena, Siena, Italy;
Alessio Casucci, DDS, Department of Fixed Prosthodontics and Dental Materials, University of Siena, Siena, Italy;
Daniele Casucci, DDS, Department of Prosthodontics, University of Siena, Siena, Italy;
Claudia Mazzitelli, DDS, MSc, PhD, Department of Fixed Prosthodontics and Dental Materials, University of Siena, Siena, Italy;
Andrea Borracchini, Associate Professor and Chair of Prosthodontics, University of Siena, Siena, Italy.

Corresponding Author: Prof. Andrea Borracchini, University of Siena, Department of Prosthodontics and Restorative Dentistry, Policlinico "Le Scotte" viale Bracci, 1 53100 Siena, Italy. Tel. +39.0577.233118, e-mail: borracchini@unisi.it

Introduction

Phonetics is the complex phenomenon of the emission of voice, the combination of phonemes at different frequencies. The sound of each person's voice is unique and is generally determined by the size of the resonator system (oral cavity, larynx, pharynx, vocal folds, nasal sinus), which vibrates at different frequencies, producing various sounds.

It is claimed that a prosthesis can modify phonetics, even if it is functionally and aesthetically well designed. Certain

Authors consider phonetics an important satisfaction factor for patients.¹

Several Authors investigated speech disturbances in complete denture-wearing patients. Heyink et al.² reported that 21% of denture-wearing subjects (28 of 131) from an elderly Dutch population had speech defects. Lundqvist et al. reported that 60% of their patients who wore a removable or a fixed prosthesis experienced phonetic problems. This percentage was reduced to 30% three years later.³

The gap between the alveolar mucosa and the framework in a screw retained implant supported prosthesis is the main cause of disturbance in word articulation.^{4,5,6} This problem does not occur with complete dentures as the hard palate is completely covered. However, this type of rehabilitation can interfere with phonetics and result in patient dissatisfaction.⁷ When the hard palate of a patient with natural teeth was covered for experimental reasons, consonant articulation was irregular, even after a long period of adaptation.⁸

Phonetics is a fundamental feature of prosthetic rehabilitation and, if not adequately considered in the treatment plan for a fixed or removable reconstruction, satisfactory results cannot be obtained.

The aim of a well-designed prosthesis is not only to restore proper function and aesthetics, but also to facilitate acceptable phonetics.

The loss of one or more teeth can alter phonetics.⁹ Spaces created by tooth loss are, at times, closed by the tongue, lips or cheeks. Phonetic articulation is often difficult, and can cause increased salivation. A satisfactory result can only be achieved if the natural structure of the arch (before tooth loss) is restored with the new prosthesis. A correct prosthetic treatment plan should include detailed occlusal, functional, aesthetic and phonetic analyses.

The loss of one tooth in the premolar or molar area seldom gives phonetic disturbances, but the loss of two or more teeth in the anterior region of the arch usually causes speech problems.¹⁰

Runte et al.¹¹ based their analysis on the inclination of the maxillary anterior teeth in relation to changes in phonetics. The study revealed misarticulation, particularly of the phoneme /s/, when the inclination of the anterior teeth increased, in both labial and palatal directions. Among the sounds formed in the anterior maxillary region, the /s/ sound is most frequently distorted, possibly because the /s/ sound formation needs particularly fine adjustment

of the tongue and depends on specific neuromuscular ability. The inability to pronounce sibilant sounds correctly is referred to as sigmatism.³ For this reason, the /s/ speech sound was chosen for this study.

Renata et al.¹² analyzed the interocclusal distance during the pronunciation of the phonemes /m/ and /s/ in the Portuguese language by edentulous patients and, subsequently, by the same patients wearing complete dentures. They concluded that in complete denture rehabilitations a correct vertical dimension of occlusion changes the interocclusal distance and, consequently, phonetics, especially in phonemes /m/ and /s/.¹³

The maintenance of a correct freeway space is fundamental to restore a good phonatory space.

The vertical dimension of occlusion in rest position and in centric occlusion has been deeply analyzed since the '50s and '60s.^{14,15}

Pound developed a technique to determine the vertical dimension based on the concept of the freeway space during the pronunciation of the phoneme /s/.¹⁶ During the pronunciation of the phonemes /i/ and /m/, muscles in the oral cavity assume the rest position,¹⁷ which is an important feature in determining the vertical dimension of occlusion.

Recent developments in multimedia techniques and software have resulted in improved evaluation of the voice and, consequently, the effects of prosthetic rehabilitation on phonetics.

The aim of this pilot study was to examine phonetic changes related to setting the anterior teeth on the crest of the alveolar ridge in maxillary complete dentures, in male and female subjects.

The null hypothesis is that, from a phonetic perspective, there are no statistically significant differences between the two groups of patients (with maxillary complete dentures with a correct arch form, and with maxillary complete dentures with the anterior teeth set on the crest of the ridge).

Materials and methods

Six edentulous subjects, who needed new dentures, were randomly recruited from the Department of Prosthodontics of the University of Siena. The sample was divided into two subgroups according to gender - the first consisting of 3 males and the second consisting of 3 females.

The new dentures were constructed with attention paid to the vertical dimension of occlusion and anterior tooth positioning. The vertical dimension of occlusion was



Figure 1: Anterior tooth position.

determined with the pronunciation of /s/, according to Pound's suggestion. Maxillary anterior teeth were placed labial to the crest of the alveolar bone, 8-10mm anterior to the incisal papilla.

Wax duplicates of the new dentures were made to replace smaller anterior teeth (A24 Ivoclar Vivadent) in a more palatal position, on the crest of the ridge, in the duplicated denture (Figure 1). A silicon mould (Platinum 95, Zhermack, Badia Polesine Italia) was used for the duplication of the dentures in order to maintain the position of the teeth. Hot liquid wax was poured into the silicon mould to replicate of the denture (Figure 2).

The well-established speech analysis programme Multi-Speech (KayPENTAX Corp, 2 Bridgewater Lane, Lincoln Park, NJ, USA) was chosen for the present study. Multi-Speech software provides a series of electro-acoustic analytical parameters for the evaluation of the voice, which can then be "visualized" through spectrograms and sonograms.

The subjects were asked to pronounce the Italian word

"sasso" to analyze the /s/ speech sound. Each patient was recorded pronouncing the word "sasso" eight times while wearing the correct dentures. The same recording was performed with each subject was wearing the prosthesis with the anterior teeth placed more palatally. The speech samples were recorded directly into the Computerized Speech Lab (Multi-Speech; Model 3700, KayPENTAX, Lincoln Park, NJ, USA) in a quiet room to ensure high recording quality. A microphone (Sony Fv-120, made in Londerzeel Belgium) was set at a distance of 10cm from the mouth. Both recordings for each subject were performed at the same energy level, in order to compare the tracings with those with the correct tooth position and those with the palatally placed teeth.

The analysis performed using the Multi Speech software was completed using the Fast Fourier Transform (FFT) power spectrum.

The speech signals were first digitized so that they could be used with the software. The Fast Fourier Transform amplified the recordings and the data obtained visualized



Figure 2: Prosthesis duplication.

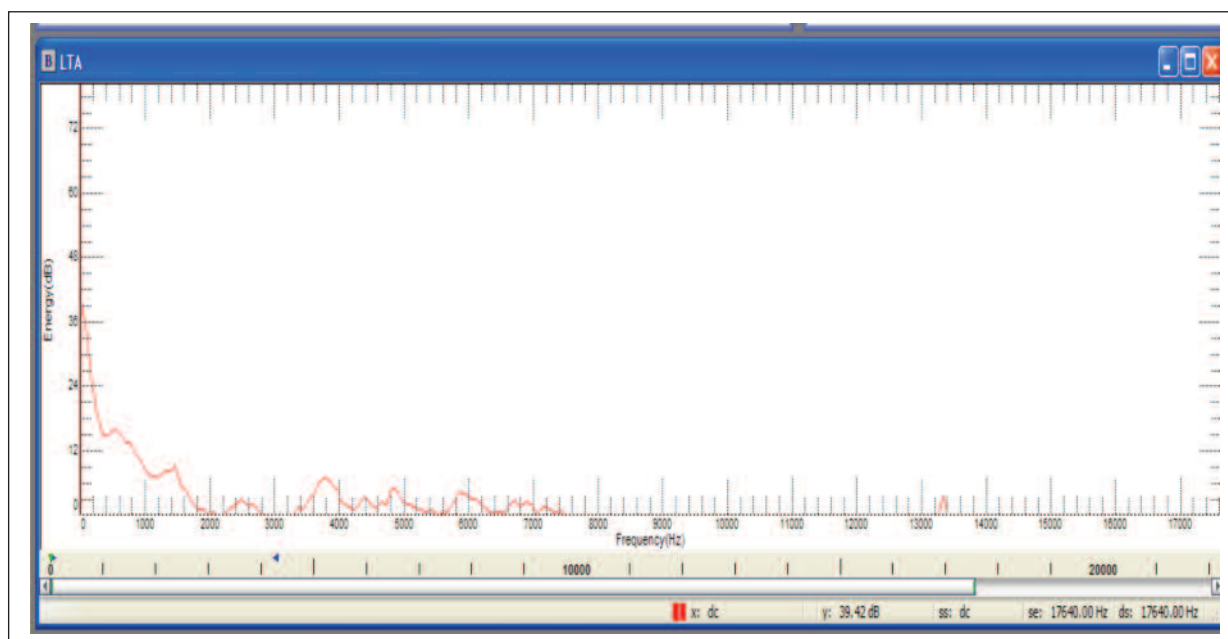


Figure 3: LTA representing the pronunciation of the Italian word "sasso" by a man with natural dentition.

in 2-dimensional Cartesian coordinates (LTA), with energy values (dB) on the y axis and frequencies (Hz) on the x axis. The means of the resulting data were calculated and represented in the 2-dimensional Cartesian coordinates (LTA). In Figures 3 and 4 the LTAs of the pronunciation of the Italian word "sasso" by a man and a woman with natural dentition are represented. In the present study, two LTAs were obtained: one representing the resulting tracing when the male sample wore a correct denture and the tracing when they wore the denture with the anterior teeth set on the crest of the ridge. The second LTA represented the resulting graph when the female sample wore the correct denture and the graph when they wore the denture with the anterior teeth set up more palatally.

The statistical analysis was performed with SPSS version 13.0. The Kolmogorov-Smirnov test was applied to the sample to verify its normal distribution and the differences between the mean values were analyzed with the Paired T-test.

Results

The mean average values of men who wore complete dentures with correct arch form and dentures with palatally positioned anterior teeth are represented in Figure 5.

When teeth were in a more palatal position, the energy in low and intermediate frequencies was increased. An

energy peak was noted in high frequencies, at a mean of 2,5 dB.

The same analysis was applied to the female sample (Figure 6).

When women wore a complete denture with palatally placed anterior teeth, energy was lowered in intermediate frequencies and, contrary to the male sample, there was a high energy peak in high frequencies.

The differences between the mean average values within each group were not statistically significant.

Discussion

There are various causes of speech sound problems in maxillary complete denture wearers. These include the labial or palatal displacement of the anterior teeth; the coverage of the hard palate; an incorrect vertical dimension of occlusion; artificial teeth which may disturb the air flow, causing misarticulation; the concave shape of the palatal vaults of maxillary complete dentures.¹⁸ In the construction of a removable denture, the design of the alveolar area is crucial because, during speech, the tongue comes into contact with sections of teeth, alveolar ridge and hard palate.¹⁹

The reduction of the volume of the oral cavity could be another cause of phonetic alterations. A more palatal

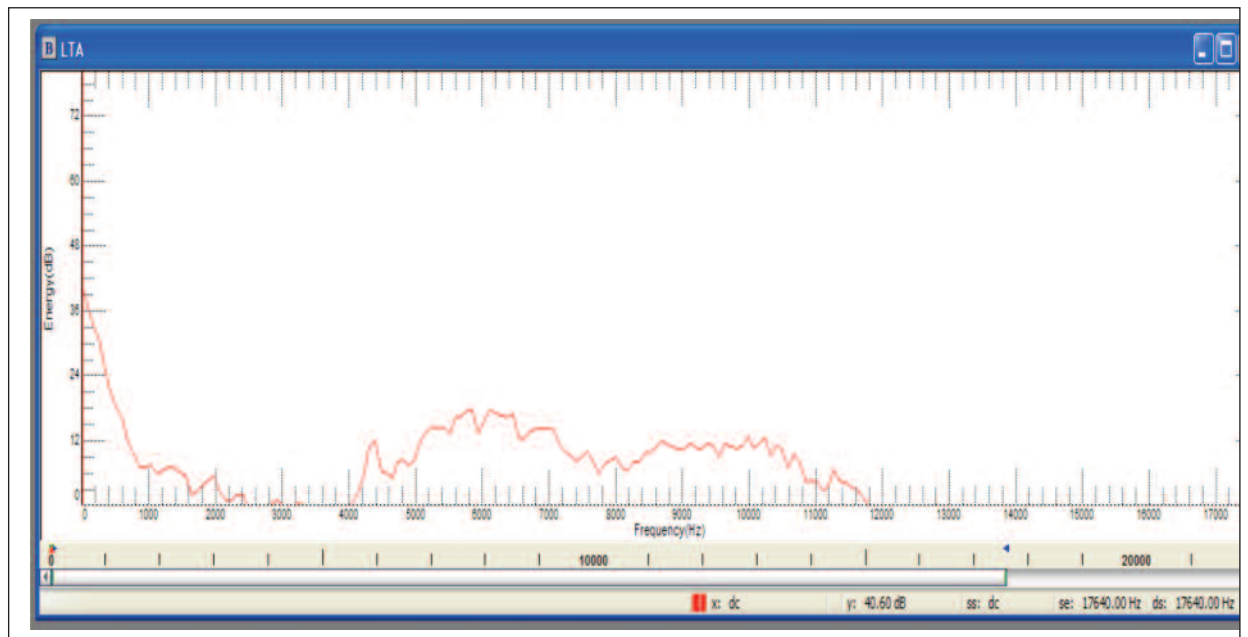


Figure 4: LTA representing the pronunciation of the Italian word "sasso" by a woman with natural dentition.

position of the anterior teeth of a maxillary complete denture, as tested in the present study, reduces the oral cavity volume and changes the "S channel", in both men and women.

Men and women have different speech sound amplification, because of their different oral cavity volume. In the comparison between the LTAs when the subjects wore a correct complete denture and one with the anterior

teeth set on the ridge, the energy levels expressed in the 2-dimensional Cartesian coordinates were different. Men, in particular, have higher energy levels in low frequencies and this meant that the male subjects had to pronounce the /s/ with more energy to speak at the same frequencies. Women have lower energy levels when they wear a denture with a anterior teeth set up at the crest of the alveolar ridge and this is a result of the adjustment of

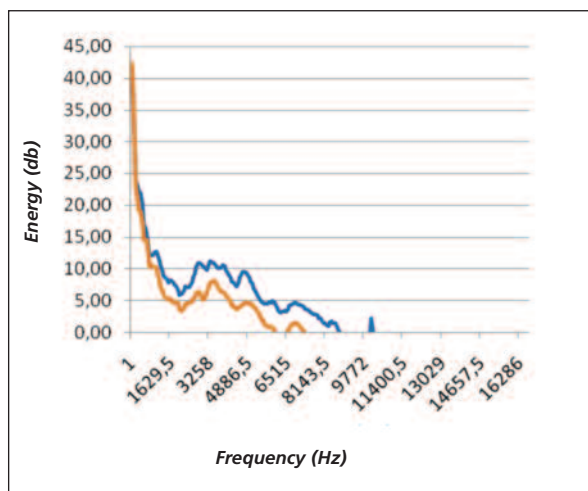


Figure 5: Mean values for men of the sample represented when they wore a correct denture (red line) and the same denture with anterior teeth set on the crest of the ridge (blue line).

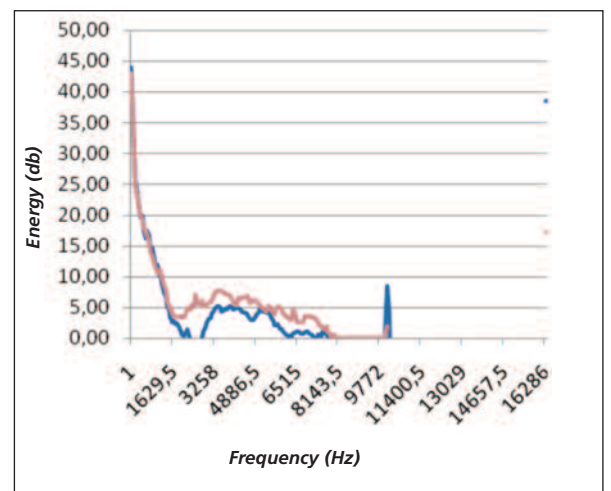


Figure 6: Mean values for women of the sample when they wear a correct denture (red line) and the same denture with anterior teeth set on the crest of the ridge (blue line).

women have to make to speak at the same frequencies when wearing a complete denture with correct anterior tooth positioning. In the LTA of the female sample there was an energy peak in high frequencies, identified as a real speech defect or "whistle", which reached almost 10 dB. In other words, both men and women had more difficulty speaking at normal frequencies when they wore a complete denture with the incisors set up on the crest of the ridge.

A rule to create an acceptable maxillary complete denture from the phonetic perspective is to set up the incisors 8-10mm labial to the incisal papilla, as suggested by many Authors.

One of the most common mistakes in complete denture fabrication is setting up maxillary incisors on or too close to the crest of the ridge, which could lead to poor aesthetics as well as phonetic defects and misarticulation.

Conclusions

Within the limits of the present pilot study it can be concluded that anterior teeth set up too far palatally (or too close to the ridge) in a complete denture appeared to have a negative impact on speech sounds. It was demonstrated that when all the subjects of the sample wore a denture with a more palatal anterior tooth position, there was an adjustment in the 2-dimension Cartesian coordinates (LTA) of the mean values of their speech energy. The mean values show that men need to pronounce the word "sasso" with more energy to be acceptable phonetically. Conversely, women use less energy to pronounce the same word but have a misarticulation (the peak energy in the LTA in high frequencies), heard as a "whistle". Nevertheless, speech defects were present both in the male and in the female groups.

The statistical analysis didn't give any significance of the data obtained, which may be due to the limited sample.

Further studies with deeper investigation of phonetics in patients who wear complete dentures are recommended.

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