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The Influence of the Design of Removable Dentures on Patient's Voice Quality

Kristine Broka, Aldis Vidzis, Juris Grigorjevs, Janis Sokolovs, Guntis Zigurs

SUMMARY

The main condition for speech intelligibility is the specific anatomical characteristics of the human speech apparatus and harmonious work of all organs in the human vocal apparatus. The voice quality is characterized by speech intelligibility (relationship between the voice pitch, volume, timbre and speech speed). Improper functional quality (related to retention,support, stability), inappropriate design of the prosthetic base and disposition of artificial teeth are the basic reasons for dyslalia – impairment of utterance with abnormality of external speech organs. In the case of dyslalia a patient may suffer from a defective utterance of separate phonemes. When designing removable dental prostheses, it is important to evaluate the disposition of the artifical teeth (taking into account phonetic pronunciation), make a phonetically beneficial construction of the base of the dentures and restore the lost alveolar bone with the basis of removable prostheses.

The aim of this study was to review literature on voice quality and the way it can be affected after the insertion of removable dental prostheses and to research the literature describing the ways how voice quality can be improved.

The literature reviewed in the paper was retrieved from Science Direct, PubMed, MD Consult, Cochrane Libary databases and dates back to the period from 1990 to 2012.

Key words: removable dental prostheses, pronunciation, impairment of utterance, hyponasality, hypernasality.

INTRODUCTION

Human speech is a result of the following physiological processes: respiration, phonation, resonance, speech articulation, audition, neurological function, emotional behavior (1, 2). The voice of each person 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 (1-3). The voice quality is characterized by speech intelligibility (relationship between the voice pitch, volume, timbre and speech speed). Changes in the oral cavity resulting from the loss of teeth and the resorption of the processus alveolaris maxillae or the processus alveolaris mandibulae, may cause defects in the patient`s voice and speech. One of the most frequent phonetic distortions is lisping (4). Omission, substitution, distortion, addition and nasality are also possible when improper and functionally low quality dentures are used (4, 5). Restrictions or alterations of the normal mandibular movement may impede the transmission of acoustic energy through the oral cavity, thereby affecting both oral resonatory characteristics and oral/nasal resonance balance (5-7). The phonetic adaptation of the patients with complete dentures depends on selection and placing of the artificial teeth, the thickness, size and placement of the maxillary prosthetic base, the optimal space of the tongue, individual adaptation capacity, patients` sound recognizing capacity (8, 9, 10). Effective speech requires teeth (11). The sounds [t], [d], [n], [s], [z], [l] in Latvian language are formed by the tongue contacting or valving against the teeth. The sounds [š] (IPA [ʃ]), [ž] (IPA [ʒ]) are formed at

[1]*Department of Otorhinolaryngology, Riga Stradins University, Riga, Latvia*
[2]*Department of Prosthodontics, Riga Stradins University, Riga, Latvia*
[3]*Latvian Language Institute of the University of Latvia, Riga, Latvia*
[4]*Department of Otorhinolaryngology, Riga Stradins University, Riga, Latvia*

Kristine Broka[1] *– PhD student*
Aldis Vidzis[2] *– D.D.S., Dr.med., assoc.professor*
Juris Grigorjevs[3] *– Dr.philol., researcher*
Janis Sokolovs[4] *– Dr.med., professor*
Guntis Zigurs[2] *– D.D.S., Dr.med., assoc.professor*

Address correspondence to: Kristine Broka, Department of Otorhinolaryngology, Riga Stradins University, 45 Vienibas gatve, Riga, LV-1004, Latvia.
E-mail address: broka.kristine@inbox.lv

the alveolar ridge, directing air streem at the edges of the upper teeth. Improper positioning of the anterior teeth and vestibular placement of the basis inhibit the tongue and the lips from producing good sounds (12-14). Some authors recommend to pay special attention to the dental [t, d, s, z], labiodental [f, v], bilabial [p, b] and velar [k, g] consonants. These consonants are more prone to distortion if the dental prostheses are made with the lingual placement of artificial teeth (12, 14). Proper positioning of the artifical teeth, appropriate design and functional quality of dental prostheses, small changes in the prosthetic field and full adaptation to the foreign body, the dental prosthesis in the oral cavity, are important factors in improving speech intelligibility (1, 11, 14-16).

THE RELATION OF CONSTRUCTION OF REMOVABLE DENTURES TO PATIENT`S VOICE QUALITY

The basis of maxillary dentures is a very important component in the construction of dental prostheses. The basis of maxillary dentures provides stability of dentures and it is necessary for speech formation and intelligibility. The basis of maxillary dentures change articulation areas of phonemes in the oral cavity and may impair tongue movements (15-17). It is necessary to make dental prostheses as thin as possible for the right formation of phonemes and speech intelligibility. The thickness of the basis of maxillary dentures should be approximattely 1, 4-2 mm in order to ensure good speech (9, 10). The tongue movement against the one third of mucous membrane of the hard palate and anterior surface of incisors provide the formation of consonants in more than 90 % of occasions. Therefore the basis of prostheses should not cover these regions since it may provoke defects in the placement of the teeth rows (18-21). There are authors (12, 21) who consider that it is necessary to dig the physiological projections of the hard palate (the incisal papilla and the ruga palatina) into the basis of the maxillary dentures. It is done to improve the formation of phonemes and pronunciation of the consonants /t/, /d/, /l/. Though there are authors who think that these physiological projections are not necessary, even more the ruga palatina and the incisal papilla may obstruct the air flow through the oral cavity and render the basis of maxillary prostheses thicker, that may impede correct pronunciation of phonemes (18-22). It is necessary to keep the configuration of the prosthetic field with the basis of dentures. If the prosthetic field is changed thoughtlessly, the adaptation to dental prostheses would decline, thus, speech intelligibility would deteriorate (10, 23).

It is necessary to make the lower dental prostheses with concave surfaces both from the tongue and the cheek sides. In that case, the tongue from one side and the mucuous membrane of a cheek from another one will press on the basis of dentures (19). Thus, it will provide better stability of the dentures, improve the functional suction of dental prostheses and phonetic pronunciation, because the chance of air flow getting under the prostheses will decrease (15, 17-21). It is necessary to keep the configuration of the hard palate and do not decrease the space of prosthetic field artificially with excessively reconstructed regions of the alveolar protuberances, when the basis of dentures is made (10, 15, 19). It is practical to make a salient surface when the metallic basis of the prostheses (also the major mandible conector) is made, thus, increasing phonetic adaptation and decreasing the feeling of a foreign body in the oral cavity (9, 10, 18-21). The orientator of the distal frontier of the basis of maxillary dentures is determined by the line „A" to total teeth loss and unlimited defects of teeth rows. The line „A" is the border between hard and soft palates (18, 20, 21). If the distal frontier of the basis of maxillary dentures was formed incorrectly, it would lead to excessive strain or relaxation of the velopharyngeal valve (1, 4, 5, 24). The velopharyngeal valve consists of the following structures: velum (soft palate), lateral pharyngeal walls, posterior pharyngeal wall (24-26). In order to produce most speech sounds, the velum raises too close against the posterior pharyngeal wall. At the same time, the lateral pharyngeal walls move too close against the soft palate. This results in a sphincter-type closure. Consequently, the entrance of the nasal cavity is blocked. In the Latvian language, the only nasal sounds are [m], [n], [ņ] (IPA [ɲ]), when velopharyngeal valve is opened and the air flow from the lungs is directed both to the oral and nasal cavities (25, 26, 27). If the velopharyngeal closure works incorrectly, the changes of resonance in the mouth, throat and nasal cavities would occur like hypo or hypernasality, thus affecting voice qualities: voice volume, harmony and correct pronunciation of phonemes (4, 5, 24-27).

THE INFLUENCE OF DISPOSITION OF THE ARTIFICIAL TEETH ON VOICE QUALITY

The position of artificial teeth is a very important factor influencing the voice quality after the insertion of dental prostheses. It is proved (1, 11, 12, 28) that the dental consonant /s/ is mispronounced

most frequently, because the production of the /s/ sound requires very precise placement of such phonetic articulators as tongue position and a narrow stream of air across the incisal edges. Therefore, this phoneme is often used for phonetic tests when the front artificial teeth are mounted (1, 11, 15, 29-31). Consonant /s/ is pronounced when the tip of the tongue touches the incisors. A narrow fissure is formed in the middle, between the anterior part of the tongue and the alveolar ridge. A specific noise (it simulates a whistle or hiss) appears when expiratory air flow runs out through this narrow gap. This narrow fissure determines precise pronunciation of the consonant /s/ (1, 13). If the narrow fissure is made wider than it is physiologically necessary, phoneme /s/ would sound inaccurate, unintelligible. A more palatal position of the anterior teeth of complete maxillary dentures reduces the volume of the oral cavity and changes the „S channel" thus resulting in misarticulation of this sound. The [s] sound is also the critical guide to estasblishing the vertical dimension of occlusion for edentulous patients. It is important to notice that the soft palate fully closes the nasal cavity when the phoneme /s/ is pronounced. Accordingly, the air flow through the nasal cavity is blocked (1-3, 13, 14, 32). The smallest speaking vertical dimension or closest speaking space is determined when the dental [s, z], alveopalatal [š, ž, č (IPA [tʃ])] consonants are pronounced. The closest speaking space method is to assess the mandibular position during production of certain speech sounds. The aim of the closest speaking space method in determining occlusal vertical dimension for edentulous subjects is to provide an interocclusal space of about 2 mm between the incisor teeth during the pronunciation of sounds [s, z, š, ž, č] (18, 19, 32). Resorption of the alveolar bone may influence the choice of the disposition of artificial teeth when removable dental prostheses are made (5, 29). The anatomical orientators of the location of natural teeth is a very important factor when setting up the anterior teeth. Many authors believe that the incisal papilla and the ruga palatina are the most reliable orientators because resorption of the alveolar bone does not affect them (2, 12, 18, 19, 33). Some clinicians suggestion (10, 18) of setting up artificial teeth in the middle part of the alveolar process of maxilla in order to stabilise the dentures, is not correct. The clinical experience (18, 20) shows that only restoring location of the teeth rows and its correlating to the place they have been before and constructing right relations between occlusion and articulation of the artificial teeth can provide the stability of dentures (9, 10, 18). Accordingly, the prosthetic field is renewed, and the phonetic adaptation is increased. Placement of the artifical teeth in the middle part of the alveolar process of maxilla narrows the space of the oral cavity, changes localization of places of the tongue contacting with the tissue of the prosthetic field and decreases good sound pronunciation (10, 33, 34). Also bilabial consonants /p/, /b/ are used for phonetic tests to estimate the position of the artificial teeth (1, 8, 12, 14). Sounds /p/, /b/ are made by contacting lips. Upper and lower lips close tightly together and seal the air flow. After a short moment the air flow is released with or without a voice sound (1, 13). The incorrect pronunciation of these consonants indicates that the vertical dimension of the anterior teeth of the maxillae is excessively elevated and the anterior teeth are lodged forward excessively (1, 8, 12, 14). The labiodental consonants /f/, /v/ are also used in the tests. Sounds /f/ and /v/ are made when the lower lip with its inner side lightly presses the lower edge of the superior teeth and the flat fissure is made. The air flow, that runs through this fissure, makes sounds that are detected, as sounds /f/ and /v/ (1, 13). If the upper anterior teeth are too short, /v/ will sound like /f/, if they are too long, /f/ will sound like /v/ (1, 12, 14, 34). Velar consonants /k/, /g/ are formed when the posterior part of the tongue is pressed to the posterior part of the hard palate or the anterior part of the soft palate (13). For good pronunciation of these consonants it is important that the distal frontier of complete dental prostheses is smooth and is adhered to the prosthetic field (1, 18, 19, 21).

It is recommended to construct the mandibular dentures according to the neutral zone concept. The central thesis of the neutral zone approach is to position artificial teeth and develop the external surfaces of prostheses so, that all of the forces exerted by the oral and para-oral musles are neutralized. Thus, the dental prostheses are maintained in a state of equilibrium. It is considered that making dentures according to the neutral zone concept could provide more stability, retention, comfort and better phonetic quality for patients (3, 18, 19, 34).

THE CHANGES OF RESONANCE AND THE METHODS OF RESEARCH

Resonance is one of the most important characteristics of the human speech. The resonance depends on the age, gender, spoken language, phonetic environment of the pronunced sounds, models and speech conventions (6, 35, 36). Dental prostheses can alter resonance, resulting in increase or decrease of nasalance. There are some authors who do not

believe that increased nasalance score among the elderly is caused by generalized neuromuscular weakness of the velopharyngeal mechanism. Indeed, evaluation of the velopharyngeal system using aeromechanical techniques has revealed that quality of closure does not change with healthy aging (5). There is a reference, that if the distal frontier of the basis of complete maxillary dentures is formed incorrectly, it would affect proper velopharyngeal closure and alter resonance. Therefore, the shape of the hard palate and the topography of the distal frontier of the basis of complete maxillary dentures have to be considered individually (4, 5, 18, 24). It is not known if or to what extent complete maxillary dentures alter the resonating characteristics of the oral cavity or the transfer of acoustic energy into the nasal cavity during speech. There exist two hypotheses. The first hypothesis claims that the basis of prostheses, which covers the entire hard palate and extends onto the soft palate, could impede the passive transmission of sound waves into the nasal cavity, thus reducing the overall nasal energy in the nasalance ratio, resulting in decreased nasalance (2, 5, 6). The second hypothesis claims that the presence of dental prostheses would decrease the volume of the oral cavity and increase oral impedance thereby reducing the oral energy component, what results in increased nasalance. Thus, dental prostheses can alter resonance, but the passive acoustic effect on the oral/nasal resonance balance, related to the presence of dentures, is not fully understood (2, 5, 6).

Spectrograms and palatograms are non-invasive research and evaluation methods to estimate voice quality. For the best analysis of the phonetic spectral characteristics in the spectrogram (1, 7, 12, 22), it is necessary to use words that contain both, consonants and vowels. If the artificial teeth are mounted incorrectly or the basis of dental prostheses is too thick, that would lead to spectral changes of the phonemes. The time and intensity of pronunciation of phonemes may be modified. The time of pronuciation of phonemes will increase, but the intensity will decrease (3, 22, 31, 38). Palatography method consists of analyzing the contact area where the tongue touches the hard palate during articulation. The relation of configuration of the hard palate to position of the tongue articulation and its changes after the insertion of dental prostheses, can be judged with the palatography as well (1, 8, 39). However, the palatography is a rather conditioned method to evaluate speech quality (18, 39). There are no definite norms to evaluate the results that are obtained with palatography. Palatograms of the announcers and speech artists were used to determine the parameters of palatography. These norms of palatography were compared with the parameters of palatography of the patients with dental prostheses inserted (1, 8, 18, 39). Speech production has a signifficant effect on patients` general satisfaction with the dentures (16, 40). Different studies revealed (1, 15, 22) 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 precondition for good sound pronunciation (10, 22). It should be noted that patients` satisfaction with removable dental prostheses determine and affect the individual ability to adapt to the dental prostheses, the latter being a foreign body in the oral cavity (1, 15, 16, 40).

The functional quality of dentures is important to good sound pronunciation. If the denture is not sufficiently fixed, the patient would hold it with the tongue or adhesive. Thus, discomfort and unsafety will occur (29, 40). Problems of articulation of teeth rows decrease stability of any removable construction. In such clinical cases phonetic adaptation to dentures is not possible (29, 40). To set up artificial teeth, it is important to take into account the extraoral and the intraoral clinical orientators, make a proper design of the basis of dentures (if possible, the basis of the prosthesis shoudn`t cover the articulation contact area of the tongue with the mucous membrane of the prosthetic field), and restore the position of the lost soft tissue of the face (cheeks, lips) to improve phonetic adaptation to dental prostheses and voice quality respectively (1, 2, 15, 17, 22, 40).

CONCLUSIONS

Subjects with inappropriate design of the prosthetic base, disposition of artifical teeth and functional quality (retention, support, stability) have dyslalia when pronunciation of separate phonemes is changed. The most frequent articulation defects can be classified as omission, substitution, distortion, addition and lisping. If dentures are badly constructed and they are too loose, the tongue would compensate the lack of stability of dentures and, thus, the speech intelligibility would decrease.

When designing removable dental prostheses it is important to evaluate the disposition of artifical teeth (taking into account phonetic pronunciation), and to make a phonetically beneficial construction of the base of dental prostheses. It is necessary to make the base of prostheses as thin as possible to improve

good sound pronunciation, however it is important not to change the resistance ability of dentures.

Phonemes, sensitive to distortion, are the dental [t, d, s, z], labiodental [f, v], bilabial [p, b] and velar [k, g] consonants, therefore these consonants are often used in phonetic tests when removable dental prostheses are made.

Spectrograms and palatograms are suitable methods of investigation to evaluate phonetic quality of removable dental prostheses.

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