REVIEW ARTICLE

PHONETICS AS A GUIDE FOR PROSTHETIC REHABILITATION OF PARTIALLY OR COMPLETELY EDENTULOUS PATIENTS

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ABSTRACT

Speech is the basis for communication between individuals. 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 as prosthesis can modify phonetics, even if it is functionally and esthetically well designed. Also, significant is the fact that speech mechanism is highly susceptible to degenerative diseases. Thus, came phonetic dentistry or gnathophonics. As dentists, it is our duty to not only restore the form and function of missing tooth and oral structures, but also phonetics, for the prosthesis to be physiologically and functionally sound. This paper deals with the considerations to be kept in mind while fabricating a dental prosthesis to fulfill the 3rd criteria of the 3 objectives of denture rehabilitation- mechanical, esthetics and phonetics.

KEY WORDS

Speech, Phonetics, Denture thickness, Closest Speaking Space, Teeth position, PPS

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INTRODUCTION

Human beings are the most intelligent species on earth. Their mastery over the vocal cords along with their fine neurologic control over the oral structures especially the tongue leads to the production, manipulation and articulation of sounds resulting in speech, which forms an important method of communication. Apart from communication, speech forms a vital part of one's personality, their expression of emotions and feelings, mindset and character.

Speech is a very sophisticated, autonomous and unconscious activity. It is a learned process whose production involves neural, muscular, mechanical, aerodynamic, acoustic and auditory factors.[1] It develops over a period of time. Most girls master the normal articulation of speech by 6.5 years of age whereas boys require an additional year of maturation[2]. As a learned function, speech is more easily disturbed by ablative surgery or congenital malformations, as compared to other primary functions like respiration and deglutition.[3]

Phonetics is a branch of linguistics that studies the sounds of human speech, or - in the case of sign languages- the equivalent aspects of sign.[4] Phonetics was studied as early as 2,500 years ago in ancient India, with Pânini's account of the place and manner of articulation of consonants in his 5th century BC treatise on Sanskrit. The major Indian alphabets today order their consonants according to Pânini's classification.[5] Phonetics has three basic areas of study:

1. Articulatory phonetics
2. Acoustic phonetics
3. Auditory phonetics

As dentists, we are more concerned in the area of articulatory phonetics. As the oro-dental morphological features might influence an individual speech, the dentist should recognize the possible role of prosthetic treatment on speech activity.[6] The loss of teeth and supporting structures alters the main articulatory cavity and produces a marked effect on the speech pattern proportionate to the location and magnitude of alterations. The poorly contoured replacement for a single tooth can

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cause speech impediment and larger prosthetic restoration fabricated without regard for speech articulation will impair speech until an accommodating articulation pattern is learned.[7] A very high percentage of the English-speaking sounds are produced by contact of the tongue with some portions of the palate and teeth. Since these contact areas are either replaced or covered by the complete denture, speech rehabilitation for the edentulous patient becomes the serious task of the Prosthodontist.[2]

PRODUCTION OF SPEECH

Speech production includes large number and sequences of innate and learned motor acts produced in sequences of 12-16 sounds/sec. normal functioning of speech is mainly influenced by 5 aspects.[8]

1. Initiator (motor area of the brain and nerve pathways)
2. Motor (lungs, associated muscle that supplies air)
3. Vibrator (vocal cords that give pitch to the tone)
4. Resonator (consists of the oral, nasal, pharyngeal cavity and paranasal sinuses)
5. Enunciators and articulators (lips, tongue, palate and teeth)

COMPONENTS OF SPEECH

Kantner and West divided speech into 5 components[9]

i. respiration,
ii. phonation,
iii. resonations,
iv. articulations and
v. neurologic integrations

Chierici and Lawson added a sixth component to this list - **audition** or the ability to hear sounds, which is vital for normal speech. Hearing permits receptions and interpretation of acoustic signals and allows the speaker to monitor and control speech output.[10] **Kessler (1957)** noted hearing loss seems to have a lot to do with the degree of adaptive ability to learn to speak well with dentures or allied health sciences. Successful treatment of defective speech usually requires close co-operation between the speech therapist and the practitioner in some branch of the medical or dental profession.[11]

CLASSIFICATION

In the area of articulatory phonetics, **phones** are described on the basis of the articulatory properties. Many sounds occur as noise and are unclassified, but those that are learned as speech are called **phones**. The closely related phones have been combined to form recognizable sounds and are classified as **phonemes**. The phonemes, then is a unit of speech by which we distinguish one utterance from another and which, collectively (about 44) makes up the **phonemics of a language**.[2]

According to sonority, speech is classified into **surds** [any voiceless sound which is produced by separation of the vocal folds (glottis open) with no marginal vibration. e.g.: - the initial 'h' sound as in 'huh'], **sonant** [voiced sounds and includes all vowels and vowel like sounds. They are produced by vibration of some portions of local folds to establish the original sound wave, which is augmented by cavity resonations] and **consonants** [articulated speech sounds, and all require articulation to impede, constrict, divert or stop the air stream at the proper place and time to produce the desired sound].[2]

VOWELS:- They are voiced sounds (i.e. vocal cords are actived by vibration in their production). They are free emission of a speech sound through the mouth and require subglottic pressure for production. They are classified according to the tongue positions in the oral cavity (i.e. high, mid, low) and the position of the lips. E.g.: - a, e, i, o, u [1]

CONSONANTS:- Can be voiced or breathed (produced without vibration of vocal cords). They are of following types:: [1]

Fricatives	Air is forced by tongue through a narrow aperture & is associated with friction	f, v, s, sh, th, z
Plosives	Made by explosive release of air	p, t, k, b, d, g
Affricatives	Combination of friction and explosive elements	ch, j
Nasal	Produced without oral exit of air	m, n, ng
Liquid	Produced without friction	r
Glides	Characterised by gradually changing articular shape	w, y

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According to anatomic sound production[1]

Bilabial	Made by contact of the lips	b, p, m
Labiodental	Made by contact of the upper incisors with the labiolingual centre to the posterior third of the lower lip	f, v
Linguodental	Made with the tip of the tongue extending slightly between the upper & lower anterior teeth(actually closer to the alveolus than tip of teeth)	th
Linguoalveolar	Made with the valve formed by the contact of the tip of tongue with the most anterior part of the palate or lingual side of the anterior teeth	t, d, s, z, n, l
Linguopalatal	Made by the tongue contacting the hard palate	sh, ch, j, y, r
Linguovelar	Made by raising the back of the tongue to occlude the soft palate & suddenly depressing the middle of the back of tongue releasing the air in puff	k, g, ng

DISCUSSION

1. Phonetics as a guide for determining the vertical dimension

The assessment and establishment of occlusal vertical dimension is a central tenet in the management of patients requiring any type of prosthesis.[5]

Silverman's closest speaking space (CSS) measures the vertical relation of the mandible in the phonetic method. Closest Speaking Space (CSS) is the space between the anterior teeth when the patient is speaking; according to Dr. Earl Pound, the space should not be more or less than 1 to 2 mm of clearance between the incisal edges of the teeth when the patient is unconsciously repeating the letter "S." Dr. Meyer M. Silverman termed this 'speaking centric', which was defined as the closest relationship of the occlusal surfaces and incisal edges of the mandibular teeth to the maxillary teeth during function and rapid speech; this was later called closest speaking level by Dr. Silverman and finally the closest speaking space. [The Glossary of Prosthodontic Terms, ninth edition (GPT 9)]

Silverman (1952) affirms that the CSS of each individual is constant throughout life.[3] The 'CSS Technique' has gained wide acceptance and has been used in clinical research (Pound, 1966, 1977; Gillings, 1973). Burnett and Clifford (1993) demonstrated that the CSS can be consistently determined from reading a long passage of prose, a short sentence or from pronouncing individual words, each containing the sibilant sounds. Morrison (1959) suggested using the words 'sixty-six' and 'Mississippi'. Burnett and Clifford (1993) also stated that, in clinical practice, it is justified to create a CSS of 2 mm between the incisors in denture construction.[5]

Vertical dimension can also be quantified in the physiologic relax mode, by asking the patient to pronounce letters 'p', 'b' and 'm'. Since lips part forcibly while pronouncing plosives('p' & 'b'), 'm' is used as lip contact is passive.[8]

Fymbo (1936) pointed out that defective speech is most frequently associated with increased vertical dimension which may result in difficulty in pronouncing sounds like b, m, p, f, v. Landa (1947) recommended various phonetic tests to determine proper vertical dimension using sounds such as s, c, z.[5,12]

2. Phonetics as a guide for determining the occlusal plane[5,13]

The labiodental sounds like 'f' and 'v' are helpful in determining the antero-posterior positioning of the upper incisors and the occlusal plane.

Earl Pound (2006) and Rothman R (1961) concluded that if upper anteriors are too short of occlusal plane the word 'v' will be more like 'f'. If upper anteriors are arranged below the occlusal plane, the word 'f' will be more like 'v'.

If the occlusal plane is set too high, the correct positioning of the lower lip may be difficult. And, if plane is too low, the lip will overlap the labial surfaces of the upper teeth to a greater extent than is required.

3. Phonetics to determine the antero-posterior positioning of the incisors

The upper anteriors are placed in 'f ' position and the lower anteriors in 's' position. Robinson stated that when a patient is pronouncing '5', '55', 'f' and 'v' sounds, the incisal edges of maxillary central incisors should contact vermillion border of lower lip at the junction of moist and dry mucosa and this position is referred to as 'f' position. The 's' position is achieved by setting incisal edges of four lower anteriors slightly lingual to labial edges of upper incisors with a space of 1-1.5mm when 's' or 'z' is pronounced.[8] The correct position of the maxillary anterior teeth cannot

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be established until the lower anteriors are placed in exact 's' position and satisfactory phonetics, lower lip support, aesthetics and anatomic harmony are achieved.[8,14]

Pound E.(1966) and Mehringer, E.J (1963):In setting the maxillary anterior teeth, change in any direction of the anteriors will result in improper execution of /s/ sound. The labial angulation seems to have greater effect than palatal angulation. If the lower anterior teeth are arranged too lingually, the tongue is forced to arch itself upto a higher position and the airway is too small resulting in faulty pronunciation of 's' and 'z' sounds.[5]

Relationship of upper anteriors to lower anteriors[15] :- The 'S' sound requires near contact of the upper and lower incisors so that the air stream is allowed to escape through a slight opening between the teeth.[Mehringer, E.J (1963), Rowe Arthur T(1936) and Pigno MA, Funk JJ(2003)]

Silverman (1967) stated that the 'Whistle and Swish Sounds' are produced during speech due to air abnormally passing over the tongue and through the inter-incisal space. These sounds may be caused due to decreased overjet.

4. Phonetics to determine the class of occlusion[8,14,16]

Pound suggested a technique to accurately record the patient's class of occlusion, vertical dimension, centric occlusion and incisal guidance. This technique involves determining the "S" position. From this position, allow the patient to relax in the hinge position and note the amount of retrusion. The sum of movements will indicate patient's occlusion and when closed at this position the original vertical dimension can be established.

If there is 2 to 3 mm of retrusion, the incisal edges of lower anterior teeth will be seen close to the cingulum of the upper anterior teeth. Hence, this will automatically assume a class I occlusion. If there is distal movement of anterior teeth of more than 3mm for the "S" position, the incisal edges of lower anteriors will be distal to the cingulum of upper anteriors and many a times against the palatal soft tissues assuming a class II relation. If there is no distal movement from the 'S' position, the incisal edge of lower anteriors will be positioned in edge to edge relation assuming a class III relation.[2]

5.Width of the dental arch and positioning of the posterior teeth[5,17]

Prendergast, W.K. (1935) and Sharry, J.J. (Ed), (1962) stated if the arch is too narrow, then the tongue will be cramped affecting the size and shape of the air channel resulting in faulty articulation of the consonants like t, d, l, n, s, k and c, where lateral margins of the tongue makes contact with palatal surfaces of the upper posterior teeth.

When the lower arch is too narrow, it is possible to increase the tongue space (for better function) by placing the last molars in cross bite relation. In extreme cases, the second molars are eliminated completely.[2]

6. Denture thickness and peripheral outline affecting phonetics

Thick dentures decrease the air volume and cause loss of tongue space affecting production of linguoalveolar and linguopalatal sounds. Allen (1958) found that an additional thickness of 1mm in the anterior palatal area made speech uncomfortable and indistinct.

A study conducted by Martone showed significant relationship between the thickness of the palate and amount of speech impairment. The study revealed-

1) Front vowels were more affected by palates than back vowels.

2) Consonants were affected by artificial palates more than twice as much as vowels.

3) Speech deteriorated in direct proportion to the thickness of the palate.[5]

Clemencon (1967) claimed that it is possible to increase the CSS by thickening the resin palatal vault of a complete denture which increases the VDO in cases in which it is too low from the aesthetic stand-point, avoiding contact between opposing teeth during speech.[17]

7. Phonetics and the posterior palatal seal area(PPS)[5,17]

Mehringer, E.J (1963) and Prendergast, W.K. (1935):- One of the most important area, especially for singers wearing dentures, is the PPS area. It affects the vowels 'i' and 'e' and the linguovelar consonants 'k', 'g' and 'ng'. Increased thickness in this region will result in irritation of the dorsum of the tongue, impeding speech and possibly producing a feeling of nausea.

8. Phonetics and palatal contour of denture

Leslie R Allen (1958) concluded that building the tongue palatal contact area to normal facilitated proper communication and eliminates much of the post insertion practice period.[18] This is best accomplished by systematically displaying each contact area with a palatogram and establishing the normal tongue contact. Palatogram is defined as a graphic representation of the area of the palate contacted by the tongue during a specified activity, usually speech. [GPT 9]

It can be achieved by dusting talc on the palatal region and asking the patient to pronounce specific consonants with the vowel 'o' as according to Allen, 'o' is the only vowel whose articulation consistently does not involve tongue touching the palate. E.g.:- 'ko' to study 'k', 'so' to study 's', etc.

Tanaka H. inferred that a reverse "S" curve exists in the natural anterior palate, in sagittal section from the study of the relationship between palatal contour

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and speech intelligibility. Palatal contour is crucial for the pronunciation of 's' and 'sh' sounds. Sounds like't', 'd', 'n' and 'l' are produced when the tongue is placed firmly against the anterior hard palate. Premature contact due to excessive thickness in anterior area can result in 't' sounding like a 'd'.[19]

CONCLUSION

Speech difficulty as a sequel of oral rehabilitation with any prosthesis is generally a transient problem. The denture should be such that the patient experiences minimum difficulty in every aspect (i.e. mastication, aesthetic & phonetics). This can be achieved with accurate impression, jaw relation, occlusion and processing of prosthesis. Prosthodontist and dental surgeons can very easily use the knowledge of phonation to correctly verify vertical jaw relation, plane of occlusion, tooth positioning and alignment, esthetics and deliver a successful prosthesis. Thus, for dentures to contribute effectively to the functions of speech, dentists should utilize studies in the speech science field to augment their clinical knowledge of the phonetic factor in denture construction. Finally, if the speech problem persists even after making the dentures phonetically correct, then patient's level of education or other disorders like hearing impairment must be considered.

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