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## Phonetics in prosthodontics: its clinical implications in designing of prosthesis

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### Abstract

Speech is a learned function that requires adequately developed nervous system, clear vision and hearing ability. Failure in development of any of these systems or the components involved in the production of speech will result in defective phonation. A prosthesis fabricated for a patient should be mechanically functional, esthetically pleasing and should allow proper phonation. The articulators change their shape and size in order to pronounce words. Therefore, a prosthesis should be fabricated in such a way that it does not hinder speech. A clinician may often come across situations where prosthodontic treatment is required to correct the speech. A prosthodontist, therefore must have a good understanding of production of speech and the various components of speech. This article discusses the mechanism of speech production and its role in prosthodontics.

**Keywords:** Phonetics, articulation, palatography

### Introduction

Speech is a fundamental part of human development and is the means by which a person can communicate with another. Speech may be defined as the faculty or act of expressing or describing thoughts, feelings, or perceptions by the articulation of words. Phonetics is the branch of linguistics that deals with the sounds of speech and their production, combination, description, and representation by written symbols. The production of speech requires involves neural, muscular, mechanical, aerodynamic, acoustic and auditory elements<sup>[1]</sup>. A prosthodontist should be well versed with the principles of phonation in order to deliver a prosthesis that corrects and/or allows proper speech. A major part of phonation occurs in the mouth therefore a prosthesis will have a direct impact on speech. Therefore, a prosthodontist should carefully analyse the speech of the patient and take necessary measure to achieve appropriate phonation.

### History

- In 1949 'Sears' recommended grooving the palate just above the median sulcus of the patient.
- In 1951 'Pound' was successful in improving phonetics by contouring the entire palatal aspect of the maxillary denture to simulate the normal palate
- 'Landa' suggested the use of 's' sound to determine the adequacy of 'free way space' & 'M' sound to establish a desirable 'rest position'.
- 1953 & 1956, 'Silverman' used 'speaking method' to measure patient's vertical dimension in natural teeth with dentures & without dentures.
- 'Morrison' suggested the use of the word, 'sixty six' & 'Mississippi' to determine closest speaking space
- 1967, 'Kaire' reported & determined the palatal pressure of the tongue in the pronunciation of selected palatolingual speech sounds, by electronic means under predetermined vertical dimensions of occlusion.

### Discussion

Mechanism of Speech Production

### Components of Speech

- The **motor component** consists of a pair of lung and its associated muscles that supply the air. The airstream necessary for the production of speech is generated at the lungs.
- The vibrator component includes the vocal cord that give pitch to the tone.
- The airstream generated at the lungs passes through the larynx and causes the vocal cords to vibrate. Subtle adjustments in air flow contribute to variations of pitch and intensity of the voice.

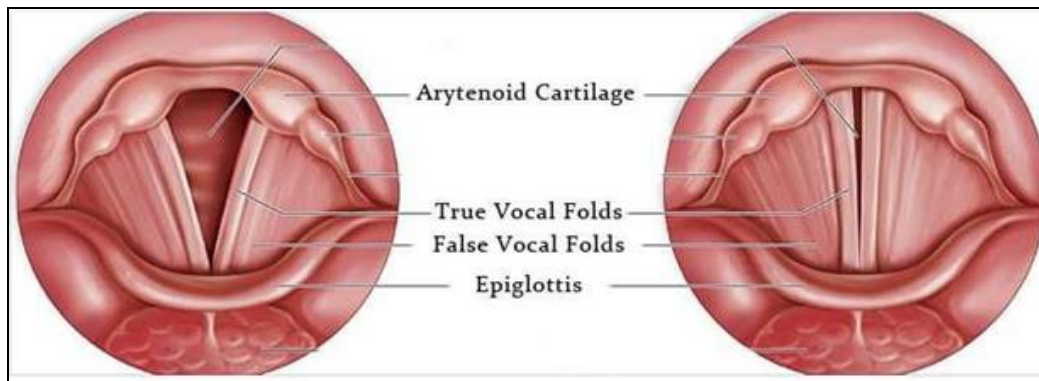


Fig 1: The vocal cords [2].

The **resonator** includes the paranasal sinuses, oral cavity, the nasal cavity and the pharynx which are responsible for amplifying the sound.

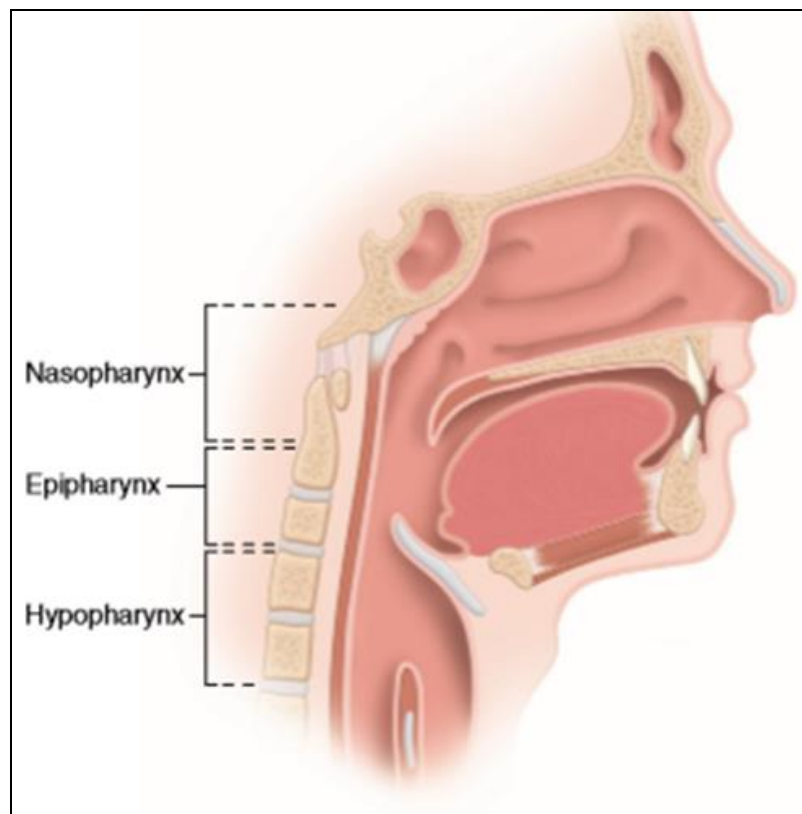


Fig 2: The different valves and articulators in the pharynx and the oral and nasal cavities that provide structural controls for speech sounds [3].

- The enunciators or articulators consist of the lips, tongue, palate and teeth which obstruct, or constricts, or diverts the airstream in a designated way in order to articulate meaning words.
- The initiator consisting of the motor speech area in the brain and the nerve pathways. Speech is a learned function whose development requires adequate hearing, clear vision and a developed nervous system. For speech, there are two very important areas in the cerebral cortex, Broca's area (after Paul Broca) and Wernickes area.

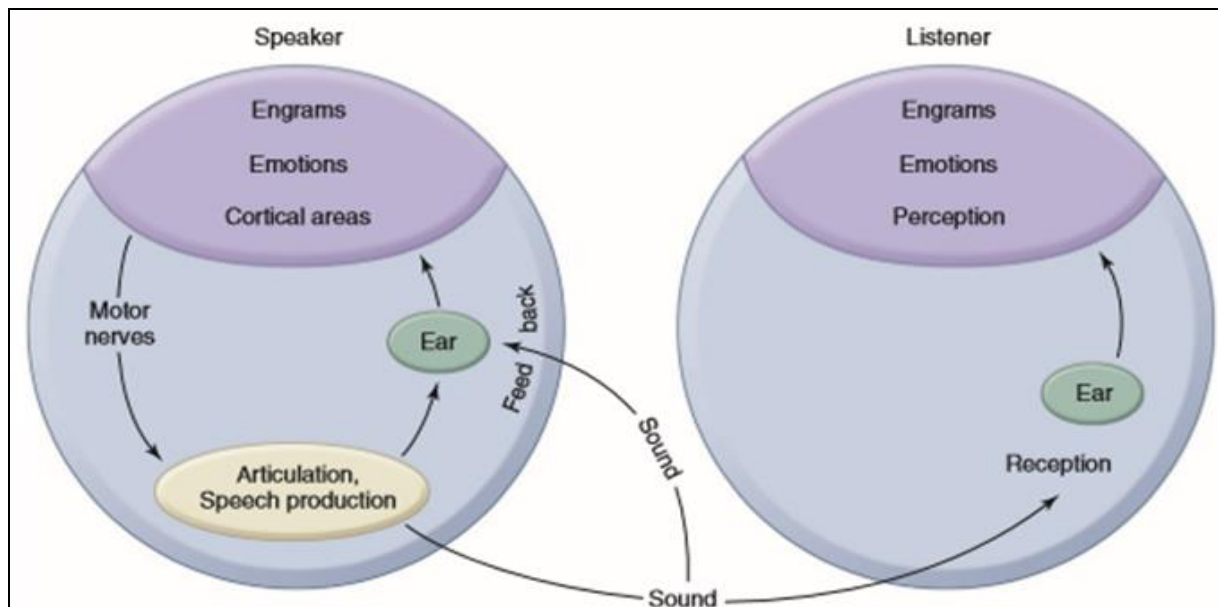


Fig 3: A general schema of speech production and communication [3]

**Valving Function**

- Speech is influenced by a series of musculoskeletal valves.

  1. Glottal valve- adduction of folds permits the production of a voiced tone and their abduction permits uninterrupted or voiceless passage of air.
  2. Palatopharyngeal valve- The muscles of the soft palate and the pharynx constitute palatopharyngeal valve, which couples or uncouples the nasal cavities.
  3. linguoavelar valve
  4. linguopalatal valve
  5. linguoalveolar valve
  6. linguodental valve
  7. labiodental valve
  8. labial valve

The various valves interrupt, impede, and constrict the air stream in many ways to produce the complete repertoire of speech sounds.

**Componentes of Speech**

- Respiration
- Phonation
- Resonation
- Articulation
- Neurological Integration
- Ability To Hear Sounds

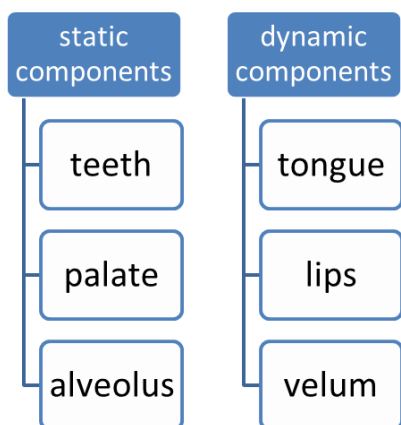


Fig 4: Static and dynamic components of speech [4]

**Classification of Speech**

1. **Vowels** : a, e, i, o, u.
  - Voiced sounds.
  - The vocal cords are activated by the production of these sounds.
  - Require sub-glottic pressure.
  - The tip of the tongue lies on the floor of the mouth either in contact with or close to the lingual surfaces of the lower anterior teeth and gums.
  - Vowel sounds are affected adversely by setting the mandibular anterior and posterior teeth lingually off the ridge. Setting the mandibular teeth too far lingually crowds the tongue in the floor of the mouth and makes the production of vowel sounds defective. The tongue is often seen to be broad after a prolonged edentulous period,so the crowding of the tongue may be experienced even when the teeth are set in the correct positions.
  - If the denture is correct phonetically for the consonant sounds, the vowels present little or no trouble [5].
2. **Consonants**: p, b, m, s, t, r, z.
  - The production of consonants requires the airstream to be impeded, diverted, or interrupted before it is released.
  - Voiced or breathed sounds.
  - Vocal cords may or may not vibrate.
  - Consonants are further divided into 6 categories:
    - Plosives/stops
    - Fricatives
    - Affricatives
    - Nasal
    - Liquid
    - Glides

**Plosive Consonants**

- An overpressure of air is been built up between the soft palate and pharyngeal wall and the airstream is then released in an explosive way.
- Examples: P, B, T, D.

**Fricatives**

- Also known as sibilants.
- A sharp and whistling sound quality is characteristic of

these sounds which is created when the airstream is squeezed through nearly obstructed articulators.

- Examples: S, Z.

#### Affricative Consonants

- Are a mix between the plosives and the fricatives.

#### Nasal Consonants

- These sounds are created without the expulsion of airstream through the mouth, instead the airstream is directed towards the nasal cavity.
- Production of such consonants involves the coupling of nasal cavity as resonators.
- Example: M, N, NG.

#### Liquid Consonants

- Also known as the semi vowels
- These sounds are produced in such a way that the airstream experiences no friction produced with out friction.
- Example: R, L.

#### Glides

- that is sounds characterized by a gradually changing articulator shape Ex: W (witch), Y (you)

#### Classification of Consonants Based On the Place of Their Production

Consonants may be classified according to the anatomic parts involved in their formation:

1. Linguopalatal sounds, formed by tongue and hard/soft palate,
2. Linguodental sounds, formed by the tongue and teeth,
3. Labiodental sounds, formed by the lips and teeth, and
4. Bilabial sounds, formed by the lips.

5. Linguoalveolar, formed by the contact of tongue and alveolus.

#### Phonetics in Complete Denture

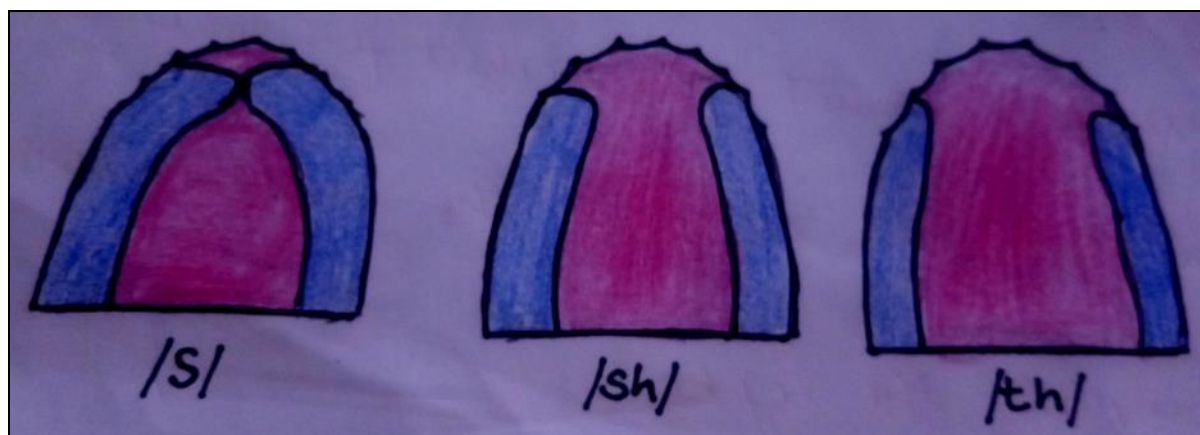
Because complete dentures may distort speech production, it can be used as a guide to position artificial teeth. However, tooth positions are sometimes critical for the production of certain sounds and not at all for others. As the teeth are being arranged for esthetics, it is not the speech sound itself that is critical but rather, the interrelationships of the tongue, teeth, denture base, and lips. Speech production made by patients at the try-in appointment can never be as accurate as when the processed acrylic resin denture base has been substituted for the trial bases, and the patient has become accustomed to the new dentures [3].

#### Linguopalatal Sounds

- a. Linguopalatal Sounds Formed By Tongue And Hard Palate

Word like S, T D N and L belong to this category  
S-Sound and Their Prosthodontic Considerations

1. Thickness of denture
2. Antero-posterior position of teeth
3. Vertical dimension of occlusion
4. Width of dental arch:
5. Relationship of upper teeth to the lower anterior teeth by "S-Position"
  - During the production of the syllable 's', the tongue comes in contact with the anterior most part of the palate just behind the maxillary incisors and the anterior teeth must come in close approximation to each other without contact. The airstream passes through a median groove formed between the tongue and the hard palate. This median groove may or may not coincide with the median raphe of the palate. A palatogram may be utilized using a maxillary trial denture base dusted with talc in order to locate this groove.



**Fig 5:** Palatograms of s, sh, and th. Note that an increase in the width of the channel corresponds to an increase in shallowness of the groove in the tongue, causing softening of s to sh and to th. A palatogram is a representation of the palate. The dark portions indicate points of lingual occlusion [5].

#### Effect of Thickness of Denture on 'S'

- Is the depth of this groove is decreased, s is softened toward sh, and as the groove is further decreased, toward th as a lisp. Excessive thickness of the denture base in the anterior part of the palate is often the cause of lisping. If this groove of the tongue is too deep, the patient may whistle while making the sound s.
- If a whistling sound is heard while pronouncing 's', then

depth of the groove of the tongue is too deep and should be made more shallow by thickening the denture base in the appropriate area.

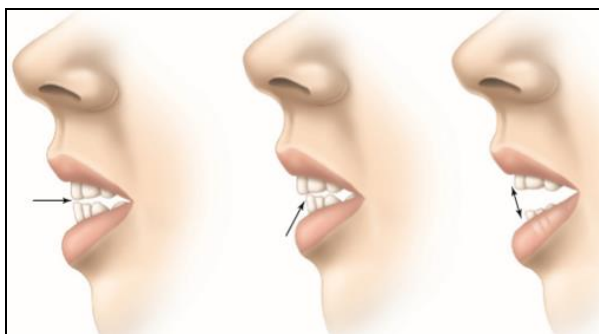
- If a lisping sound is heard while pronouncing 's', then the groove is too shallow and must be made deeper by identifying the position of the median groove and then trimming the denture base to make the groove deep enough.

### Effect of Positioning of Anterior Teeth on 'S'

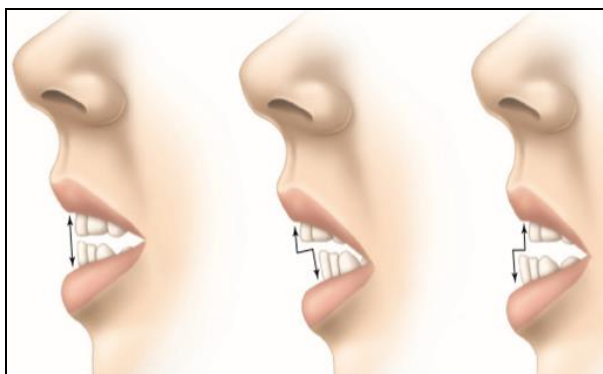
- If the mandibular incisors are set too far posteriorly, s is softened toward the lisp because the tongue is crowded posteriorly which make the groove in the tongue shallow.
- If the mandibular incisors are set too far anteriorly, then /s/ will whistle since the tongue will be overextended anteriorly and cause the groove in the tongue to deepen. The sound s will sound like sh. This occurs due to the leakage of air from the lateral borders of the tongue as the tongue is not sufficiently confined in the bicuspid region. This phenomenon, known as Stigmatismus lateralis, which may be corrected by creating palatal eminences bilaterally on the denture base corresponding to the naturally occurring prominences of the alveolar ridges in the bicuspid- molar regions.

### Effect of Vertical Dimension on 'S'

- Silverman used the sibilant /S/ as a phonetic means for determining vertical dimension. When s is pronounced, the maxillary and the mandibular teeth approximate each other but dont contact such that they are separated by only 1 or 2 mm<sup>[5]</sup>.
- If the maxillary and mandibular teeth contact each other causing a clicking sound while pronouncing these words, it will indicate an increased vertical dimension of occlusion.
- If too much space can be seen while the pronunciation of words like sixty six, it will indicate lack of vertical dimension of occlusion.



**Fig 6:** Vertical length of the anterior teeth during sibilant production from left to right is shown as correct, excessive, and with inadequate vertical overlap<sup>[3]</sup>.



**Fig 7:** Horizontal relation of the anterior teeth during sibilant production from left to right is shown as correct, excessive, and with deficient overlapping<sup>[3]</sup>.

#### a. Linguopalatal Sounds Formed By Tongue And Soft Palate

- Consonant k, ng and g are representative of the palatolingual group of sounds.

- Sound is formed by raising the back of the tongue to occlude with the soft palate and then suddenly depressing the middle portion of the back of the tongue releasing the air in a puff. If the posterior border of the upper denture is overextended or does not make firm contact with the tissue at the posterior palatal seal, the k becomes altered toward the ch sound<sup>[6]</sup>.

### Linguodental Sounds

- Consonant 'Th' is representative of the linguodental group of sounds
- The linguodental sounds are made with the tip of the tongue extending slightly between the maxillary and the mandibular anterior teeth. Air is pushed into the channel formed by the palate and the dorsum of the tongue, then the tip of the tongue is retracted into the oral cavity. As the air escapes through the space created by the retraction of the tongue, the sound th is produced<sup>[4]</sup>.

### Effect of inter arch space or the labiolingual position of the anterior teeth on 'Th'

- If about 3mm of the tip of the tongue is not visible, the anterior teeth are probably too far forward (except for class 2 malocclusions), or there is excessive overbite which doesn't allow the tongue to protrude through.
- If more than 6mm of the tongue extends out between the teeth when such sounds are made, the teeth are probably too lingual.
- Inadequate interocclusal distance may cause a sensation of tongue biting when th is articulated. The patient may tend to place the tip of the tongue behind the anterior teeth instead of between them and th will be pronounced t. Similarly, th is pronounced t when the anterior teeth are set too far lingually. The tongue becomes pressed against the lingual surfaces of the upper and lower teeth and against the linguogingival margin of the upper anterior teeth. The sound t will result from this relation of the tongue and teeth. A patient with an exceptionally retruded mandible requires an arrangement of anterior teeth with a large horizontal overlap. The linguodental sounds are difficult for such a patient to pronounce.

### Linguoalveolar Sounds

- T, D, S, Z, V are representative of the linguoalveolar group of sounds
- The tip of the tongue contacts with the most anterior part of the palate (the alveolus) or the lingual sides of the anterior teeth.
- Sibilants S, Z, SH, CH and J (with CH and J being affricatives) are alveolar sounds, because the tongue and alveolus forms the controlling valve.
- These syllables give us the relationship of the anterior teeth to each other.
- Upper and lower incisors should come in very close approximation to each other but should not touch.
- The syllables T, D, N, L may or may not be affected by the reproduction of rugae in the anterior palate. Several authors encourage this because these rugae help in the orientation of the tongue. There are authors that discourage this on the grounds that the tongue maybe cramped due to the additional thickness of the denture base and almost no resorption of the hard palate.

### Labiodental Sounds

- F and V are representatives of the labiodental group of sounds.

- Formed by raising the lower lip into contact with the incisal edge of the maxillary anterior teeth, therefore these sounds help us to determine the relationship between the same.

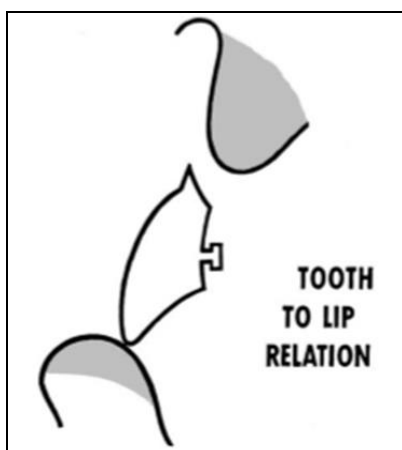


Fig 8: Relation of tooth to lip [7].

- In case the maxillary anterior teeth are too short i.e. if they are set too high up, then V sound will be more like an F.
- If they are too long i.e. if they are set too far down, then F will sound more like a V.
- If the labial surface of the lower lip contact the incisal edges of the maxillary teeth, it means that the mandibular anterior teeth are placed too far anterior or that the mandibular anterior teeth have been placed too far posteriorly.
- If the lower lip falls back while pronouncing these words, it means that the lower anterior teeth have been placed too far posteriorly
- If an imprint of the maxillary anterior teeth is formed on the mucosa of the lower lip or if the mandibular denture is lifted by the lower lip, it means that the mandibular anterior teeth have been placed too far anteriorly, consequently the maxillary anterior teeth have also been placed too far forward.

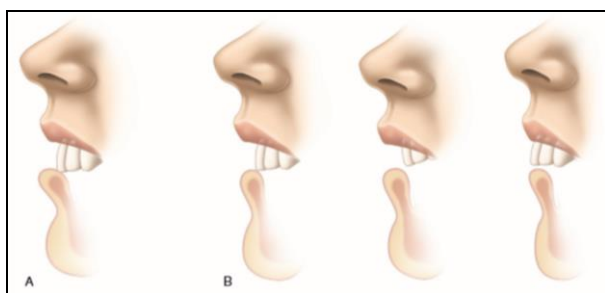


Fig 9: Effect of tooth positioning on f and v. A, Upper anterior teeth too long, During the pronunciation off, they will contact the lower lip in a position similar to v, and the sounds may sound alike. B, effect of antero-posterior positioning of the teeth from left to right are, correct, too far posterior and too far anterior [3].

### Bilabial Sounds

- B, P and m are representatives of the bilabial group of sounds.
- Formed by the stream of air coming from the lungs which meets with no resistance along its entire path until it reaches the lip. The sound m is produced in a similar manner except that the air escapes in part through the

nose as a nasal sound.

- If there is insufficient support of the lips by the teeth or the denture base can cause these sounds to be defective.

### Effect of Interarch Distance on Bilabials

- If the interarch distance is increased then the patient will not be able to close the lips comfortably to form a seal or if insufficient interarch distance exists, the lips will contact prematurely.
- Both these situations will alter bilabials.

### Effect of Correct Labiolingual Positioning Of the Anterior Teeth on Bilabials

- When the teeth are placed too far labially, the lips do not meet comfortably; with a lingual displacement of the anterior teeth, the lips meet prematurely. Therefore, the pronunciation of the bilabial sounds should be used to check the vertical jaw relation and to make sure that the lips meet comfortably without premature contact of the occlusion rims. Bilabial are also affected by the thickness of the labial flange.

### Soft Palate and Speech

- The soft palate must rise and form a competent velopharyngeal sphincter closing the nasopharyngeal space in all speech sounds except n, m, and ng. When the soft palate is inactive, the space remains open, causing a nasal tone. An overextended maxillary denture may cause irritation of the velum, with subsequent stiffening of its muscles [4].

### Prosthetic Implication In Denture Design Affecting Speech

- Denture thickness and peripheral outline
- Vertical dimension
- Occlusal plane
- Relationship of the upper and lower teeth
- Post dam area
- Anterior-posterior positioning of teeth
- Width of dental arch

### Denture Thickness and Peripheral Outline

- A denture is required to be mechanically functional, aesthetically pleasing and should also allow normal speech.
- Denture Peripheries:** Unduly thick denture bases are one of the biggest reasons for the defective phonation. Increase in the thickness consequently causes a decrease in the volume of oral cavity and loss of tongue space. The denture should be extended to as much area as possible without encroaching upon the movable tissues. Overextended peripheries of the denture will hinder the movements of the articulators while speaking. This will lead to incomprehensible speech.

- Denture Thickness:** No residual ridge resorption occurs in the palatal area. The thickness of the denture base covering the palate decreases the amount of tongue room and the oral air volume. The production of the palatolingual group of sounds involves contact between the tongue, and either the palate, the alveolar process, or the teeth.
  - With the consonants T and D, the tongue makes firm contact with the anterior part of the hard palate, if the denture base is excessively thick in this region it may cause defective formation of these sounds.
  - With the syllables S, G, Z, R and L, the tongue contacts

the most anterior part of the hard palate A median groove is formed between the hard palate and the tongue while the phonation of sounds like S, G, Z. If the denture base too thick in this area this groove is obliterated or it may become shallow as a result of which lisping occurs.

- With the syllables Gh and J sounds the tongue is pressed against a larger area of the hard palate. Again if the thickness of the denture is increased in this area, it will lead to defective phonation.

### Vertical Dimension

The bilabials such as P, B and M require that the lips contact to form a seal. With P and B, the lips part quite forcibly, but in case of the M sound, the lip contact is passive.

- The syllable 'M' is used to obtaining the correct vertical height. If there is a strained appearance during lip contact, or the lips fail to make contact, it would mean that the occlusal rims are contacting prematurely [8].
- The syllables G, S and Z when produced bring the teeth in close approximation to each other without coming into contact. If the vertical dimension of occlusion is too large, the dentures will actually make contact as these consonants are formed, and a clicking sound will be produced.

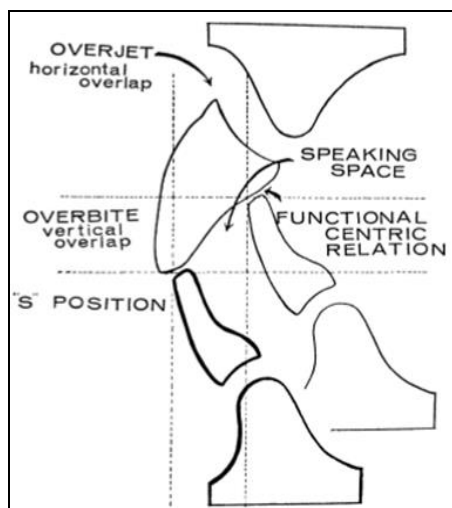


Fig 10: The S- Position [7]

### The Occlusal Plane

- Labiodental group of sounds F and V help in determining the correct occlusal plane. These are formed by raising the lower lip into contact with the incisal edge of the maxillary anterior teeth.
- In case the maxillary anterior teeth are placed above the occlusal plane, then V sound will be more like an F.
- If they are placed below the occlusal plane, then F will sound more like a V.

### The Anteroposterior Position of the Incisors

- Labiodental F, V and Ph may be used as a guide in the anteroposterior positioning of the incisors. If the teeth are placed too far palatally, the contact of the lower lip with the incisal and labial surfaces will become difficult.
- Palatolinguals, S, G (soft), and Z are also affected in this case, since the tongue will make premature contact with the incisors, this will result in a lisp.

### The Post-dam Area

- Vowels such as I and E and the palatolinguals such as K,

NG, G and G can be used to determine the extent of the post dam area.

- A denture which has a thick base in the post-dam area, or that edge finished square instead of tapering, will irritate the dorsum of the tongue, impeding the speech.
- A denture with poor palatal seal will unseat when the words requiring expulsion of burst of airsteam forcefully are pronounced. Such syllables include the plosive such as P, B etc.

### Width of Dental Arch

- A narrow arch cramps the tongue which cause the size and shape of the air channel to alter. Consequently, Defective phonation of such syllables such as T, D, S, M, N, K, G and H, where the lateral margins of the tongue make contact with the palatal surfaces of the upper posterior teeth, occurs.

### Relationship of the Upper Anterior to the Lower Anterior Teeth

The sibilant S requires near contact of maxillary and mandibular incisors so that the air stream can escape through the slight space between the teeth. The consonants Ch, J and Z require a similar air channel in their formation [9].

### Phonetics and Occlusion

#### Using Phonetics to Determine the Class of Occlusion

This technique was suggested by Earl Pound. Through this technique we can precisely record the patient's class of occlusion, vertical dimension, centric occlusion and incisal guidance. This technique involves to determining the "S" position. Allow the patient to relax in the hinge position and note the amount of retrusion. The sum of movements will indicate the patient's occlusion and also when closed at this position we will be able to make conclusion about the patients original vertical dimension. If there is 2 to 3mm of retrusion, the incisal edges of lower anterior teeth will be seen close to the cingulum of the upper anterior teeth. Henceforth this will automatically adopt a class - 1 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 cingulum of upper anteriors and many a times may be against the palatal soft tissues assuming a class -2 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, therefore assuming a class -3 relation [7].

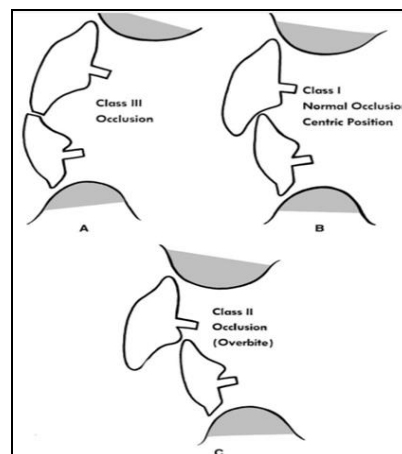


Fig 10: Relation of anterior teeth in different classes of occlusion [10].

### Phonetics and Malocclusion

The “s” sound formation may be considered the most difficult sound to produce and most misarticulated consonant that are related with the articulator structures. In subjects with ideal occlusion, it has been demonstrated that formation of an acoustically perfect “s” sound occurs when the incisors are edge to edge, molars slightly separated, the mandible lightly protruded, the tongue is consistently related to the palate and alveolar process where as the horizontal tip lies posterior to the lower incisors, while the hyoid bone is lightly elevated. Therefore the sounds that are produced in the anterior region, particularly a correct “s” sound is more difficult to produce in cases of increased over-jet. Since frontal segment of the dental arch have an important role in sibilants pronunciation, sibilant speech disorders might occur in patients with intense orthodontic anomaly of the frontal segment. It has been seen that there is a tendency for subjects with disturbance of the “s” sound to have a lightly narrower palate than the subjects with a correct “s” sound. Also, subjects that produce sounds from the posterior region had systematically higher mean values for palatal length in all segments. Earlier researchers argued the relationship between increased over-jet and speech disorders since compensatory movements allowed normal speech even in the presence of abnormal anatomical relationships. Cephalometric radiography and cine-radiographic techniques were used to study the nature of this compensatory mechanism individuals who have severe Class II malocclusion constantly have difficulty producing bilabial consonants such as “p”, “b” and “m”. By definition, the formation of these sounds requires the upper and lower lip to contact each other. Individuals who have Class II malocclusion often modify these bilabial sounds by using the lower lip in contact with the maxillary incisors. Class III subjects often have a tongue posture that is habitually low and loose. Constriction of the linguo-alveolar valve necessary for sibilants is therefore not produced effectively. Individuals who have Class III malocclusion often present difficulty in producing labio-dental and linguo-alveolar consonants “f” and “v”. These sounds require the lower lip to position nearly to the maxillary incisors. Instead of the typical place of production, Class III patients may exhibit two types of error pattern. The first common pattern is the individuals that produce these sounds with a bilabial place of production, moving the lower lip up to the upper lip and narrowly constricting the air stream at the place of articulation. The second pattern includes the upper lip slightly contacting the mandibular incisors, in a reversed labio-dental posture. Individuals who have Class III malocclusion tend to have difficulty with the consonants “t”, “d”, “l”, “n”, “s” and “z”. These sounds should be produced with tongue tip coming near the alveolar ridge. Instead, these individuals often produce these sounds with the tip of the tongue contacting the maxillary incisors. This is called dentalization. A important relationship between open-bite and anterior lisp during articulation of the linguo-alveolar consonants “t”, “d”, “n”, “l” has been found. Distortion of anteriorly produced sounds is observed in open-bite patient. It is reported that incisal open-bite alone is rarely associated with articulatory speech defects. But, if it is combined with other occlusal anomalies, more severe mis-articulations are observed. On the contrary, Bernstein reported that even though speech disorders are directly related to open bite, the severity of the lisp does not vary with the amount of the malocclusion. The spacing of maxillary incisors is associated with articulatory defects of “l”, “n”, “d” and “r” sounds. Increased open-bite and over-jet

plays a more important role than anterior spacing during pronunciation <sup>[10]</sup>.

### Phonetics in Esthetic Dentistry

Where today’s modern society demands a pleasing appearance in both personal and professional lives, it has now become a necessity to look ones best. The face is the mirror of one’s personality and the our mouth itself is a focal point of attention. Not all of us are bestowed with an esthetically pleasing smile. So, several times we might encounter patients demand an alteration of their smile. It may range from limited to anterior segment to a full mouth rehabilitation. Analysis of the smile includes a study of facial features and lip movements in line with the tooth using facial, dento-labial and phonetic parameters, in order to achieve the optimal and final esthetics. Successively dental and gingival aspect completes esthetic analysis. Careful evaluations of these parameters allow clinicians to create the restorations that are integrated not only in the oral cavity, but also in relation with patient’s facial look. Tooth visibility in relax position and mouth slightly opened and lips relaxed varies with age. Facial esthetic value depends to a great extent on tooth display in vertical dimension of the rest. This seemingly ease task actually requires a lot of skill and knowledge <sup>[11, 12]</sup>.

### Phonetics in Maxillofacial Prosthesis

Production of intelligible speech is dependent upon the controlled movement of air from the lungs through the larynx, hypopharynx, and oral cavity. The production of various phonemes and sibilants is highly dependent upon the shape of the structures as the air passes through the various chambers. In the oral cavity, the tongue, soft palate, hard palate, dental alveolar complex, buccinator muscle, and lips play an important role in the control of the shape and volume of the oral cavity in the production of speech. The tongue shapes the oral and pharyngeal cavities for vowel production. It restricts air flow in the oral cavity to produce consonants. Compromise to the tongue secondary to surgical resection, resulting in altered volume, and limited and restricted movement of the tongue, tongue segments, or flaps, can have an adverse effect upon the quality of speech. Consequently, following resection of lesions located close to the mandible, articulation is adversely affected. Lesions vary in their size and location and, therefore, the surgical and radiological treatment will vary; as will the impact upon oral structure and function. In general, following mandibular resections, the oral cavity is reduced in size and a portion of the tongue often is excised and/or used for closure of the wound. In general, the speech exhibited by most mandibulectomy patients will be understandable. The degree of impairment is related primarily to the status of tongue function. With extensive resections of the tongue and floor of the mouth, the remaining portion of the tongue may exhibit limited and imprecise movements. Partial glossectomy patients may make use of the residual tongue to perform adaptive movements approximating normal movements, whereas the total glossectomy patients develop truly compensatory patterns of speech <sup>[13]</sup>.

The tongue is one of the most important structures of the speech system. It must elevate, narrow, thin, groove, protrude, retract, and even lie flat in the mouth as it contributes to speech. Generally, it is such an efficient and adaptable instrument that, when the static structures are abnormal in some way, the tongue can make adjustments to compensate for the abnormality; yet there are limitations <sup>[14]</sup> Frahm <sup>[15]</sup> said, “While nature provides an simple degree of tolerance



and the tongue can adapt itself to changes in surface conditions, and aid in the enunciation of the patient, it is not

wise to impose too much upon such a yielding and willing member of the vocal instrument”.

Phoneme	Contact	Test Sentence
p, b, m	Bilabial contact	Bobby popped my balloon.
k, g, ng	Linguo-velar contact	Go get the coat and bring it back.
t, d, n	Linguo-alveolar contact	Tom did not do it.
f, v	Labio-dental contact	Father found some coffee.
th	Linguo-dental contact	They thought there were three.
j, ch	Linguo-palatal contact	Jack jumped by the children.
l	Lateral lingual aperture	The little lamp was lit in school.
r	Central lingual aperture	Roy Rogers' horse was Trigger.
w	Widening labial aperture	Will you go with William?
y	Widening lingual aperture	You and your young sister will go next year.
s, z	Linguo-alveolar contact	Six sisters saw the zebra in the zoo.
sh, zh	Linguo-palatal contact and wide air blade	She will wash the dish in the garage.

FIG 11: Clinical speech considerations to identify speech pathology [16].

**Analysis of Speech In Prosthodontics**

In order to acquire best possible phonetics in a patient we most essentially need to thoroughly analyse the structures that are critical to speech e.g. the alveolar ridge, and the palate, the teeth, the tongue. When speech problems are found, one approach to the analysis of these problems is to relate structure to mode. As an example, it is important to note how the tongue approaches the alveolus and directs the airstream thereupon to cause a speech sound to be made.

**Errors In Articulation**

The articulatory errors can be classified into:

- Omissions, Substitution and Distortion. Some typical illustrations of these might prove Useful.
- Omissions may be seen kids or may be heard in a person trying to learn a new unfamiliar language or a person with auditory defects. This type of articulatory

error is not so common in denture wearers.

- Substitution Error are those when a sound is replaced by some other, for example ‘think for sink’. Here the person may have replaced ‘th’ by ‘s’ sound. This is termed as lisp. We may come across prosthodontic patients exhibiting this type of error.
- Distortion is seen when a sound intended to produce is so distorted that it becomes some other word completely. The speech may become incomprehensible [8].

Table 1: Types of errors in speech [14]

Error Type	Example	Effect
Substitution	“Think” For “Sink”	“Th” Replaces “S” Sound: Wrong Word.
Omission	“Ink” For “Sink”	“S” Is Omitted : Wrong Word
Distortion	“Ink” For “Sink”	“S” Is Distorted: Wrong Is Unintelligent.

Table 2: Speech sound deviation according to structural deviation [14]

Structural Situation	Tongue Behavior	Airflow Change	Speech Effect
Tooth Position			
▪ Incisors Labial	Stretching Apex	Broadened Airstream	/Sh/ For /S/
▪ Incisors Lingual	‘Jammed Apex’	Laterized	Lateral Lisp
▪ Normal	Tongue Thrust	Turbulence Labial	/Th/ For /S/
▪ Lateral Molars	Orientation Or Fulcrum Loss	Wide Variations	‘Slushy’ Speech
Corrected Palatal Area	Orientation And Feedback Loss	Wide Variations	Imprecise Articulation
Tongue Deviation (Asymmetry And Scarring)	Gross Misplacement	Wide Variation	Imprecise Articulation

**Speech Tests**

**Speech Analysis**

- 2categories

1) Perceptual/acoustic

- Based on broad band spectrogram, recording by Sonograph • Objective opinion of performance

## 2) Kinematic movement analysis:

**Ultrasonics**

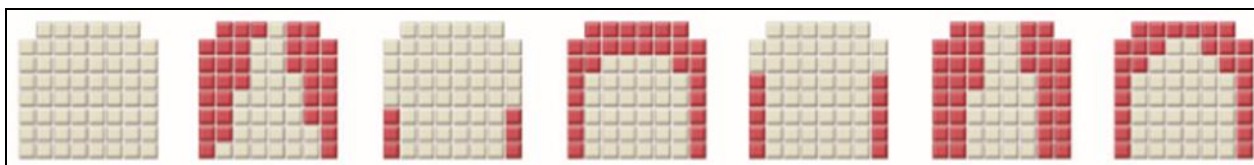
- X-ray mapping
- Cineradiography
- Optoelectronic articulatory movement tracking
- Electropalatography

**Palatography**

The tongue plays a major role in speech. It changes position and shape for the pronunciation of each of the vowels, and it is the principal articulator for the consonants. In pronouncing the consonants, the tongue contacts various portions of the teeth, the alveolar ridge, and the hard palate. Since these

structures are either replaced or covered by the denture, it was basic to the study to know exactly which portions of these structures are normally contacted by the tongue in pronouncing a given consonant. To accomplish this, palatograms were made on a group of dentulous individuals, with normal speech, who were chosen so as to incorporate a maximum variety of tooth arrangement, tooth occlusion, arch form, arch size, vault form, and vault depth<sup>[17]</sup>.

It is a group of techniques to record contact between the tongue and the roof the mouth to get articulatory records for the production of speech sounds. Palatograms are the areas of tongue contact for a given sound displayed on an artificial palate through a medium of talcum powder.



**Fig 13:** Typical electropalatography diagrams for the sounds in “oh sadist.” Shaded area represents the contact between tongue and palate. Note the sagittal groove created when the s sound is uttered.<sup>8</sup>

**Prerequisite for making palatogram**

1. The artificial palate made must be uniformly adapted, no adhesive must be used.
2. Patient who have severe gagging must not be used for making palatograms.
3. The patient has to be trained to open his mouth after uttering the desired word.
4. The tracing material must not be distasteful and its consistency should permit easy application
5. The palate has to be thoroughly dried before the medium is applied and the medium must have a contrasting colour so that it can be easily identified
6. Talc is considered the best material that can be used for palatogram, although activated charcoal, chocolate powder where also used.

**Conclusion**

- The proper knowledge of speech production and phonetic parameters will enable a clinician in fabrication of dentures with good phonetic capabilities.
- Achievement of the optimum phonetic potential is possible by providing correlation between mechanics, esthetics and phonetics.

**Conclusion**

The importance of phonetics in the field of prosthodontics is undeniable. It is mandatory for a clinician to have a working knowledge of the production of speech and the effect a prosthesis may have on proper speech. Since speech is fundamental to us therefore, it is essential that a clinician delivers a prosthesis that allows clear speech.

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