EVALUATION OF CHANGES IN VELAR STRETCH WITH AGE & CORRELATING IT WITH POSSIBILITY OF DYSLALIA: A DIGITAL CEPHALOMETRIC STUDY

Dissertation Submitted To

BABU BANARASI DAS UNIVERSITY, LUCKNOW,

UTTAR PRADESH

In the partial fulfillment of the requirement for the degree of

Master of Dental Surgery

in

Oral Medicine And Radiology

by

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Under the guidance of

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Reader

DEPARTMENT OF ORAL MEDICINE AND RADIOLOGY

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES,

BBDU LUCKNOW (U.P)

BATCH 2020-2023

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"Evaluation of changes in velar stretch with age & correlating it with possibility of dyslalia: a digital cephalometric study"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. Priya Singh**, Reader and **Dr. Neeta Misra**, Professor, Dept of Oral Medicine and Radiology, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

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Appreciation is the highest form of prayer, for it acknowledges the presence of good wherever you shine the light of your thankful thoughts.

- Alan Cohen

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Background

Dyslalia, or difficulty in articulating words, is a speech disorder that can affect both children and adults. It is caused by a problem with the articulation of speech. This can make it difficult to correctly articulate words and sentences, which can lead to frustration or embarrassment. In order to diagnose and treat dyslalia, speech-language pathologists use various assessment tools. Application of cost effective diagnostic method like lateral cephalometric radiography would be a major breakthrough.

Materials and Methods

This study include 80 subjects from both genders between the age range of 8-27 years who were subjected to digital lateral cephalometric radiograph along with Modified Informal assessment method of phonation conducted at Department of Oral Medicine and Radiology.

Result

In the present study, the velar length, velar thickness and difference in velar length and velar thickness while rest and phonation between dyslalics and non dyslalics have been assessed and a significant difference has been observed. However, insignificant results are obtained in case of effect of age in velar thickness while phonation in dyslalics.

Conclusion

On comparing dyslalics and non dyslalics, the significant difference in velar length, velar thickness and their respective difference while rest and phonation which was evaluated through lateral cephalometric radiography could serve as a cost-effective method for diagnosing Dyslalia. However, comparative evaluation between dyslalics and non dyslalics and effect of age on other structures of velopharyngeal apparatus while phonation warrant further research.

Keywords

Dyslalia, Lateral cephalograph, Velar, Velar stretch, Velar retraction, Velum

One disorder which is not often associated with dentistry, but one that is truly related to the surrounding anatomy, is Dyslalia. Simply stated, dyslalia is a disorder with disruption in the pronunciation of phonemes, which can involve changing or leaving out certain sounds or incorrectly substituting some sounds. [(1)] The use of language is seen as a key component for the development of a child's cognition, social interaction, and emotions. Hence, language enables the exchange of data and provides an avenue to communicate thoughts, emotions and experiences in order to gain access to knowledge and open doors to new opportunities. The importance of understanding this speech impairment and its early detection is becoming increasingly relevant. [(2)]

Dyslalia is a disorder that affects one's ability to correctly pronounce certain sounds or groups of sounds. It can be caused by an evolutionary factor, a functional factor, an audiogenic factor, or an organic factor. This can result in altering, omitting, or mispronouncing specific phonemes. However, not much information has been gathered and established on the aforementioned disorder on radiological basis. This method of measuring velar stretch on lateral cephalograms and correlating with Dyslalia can act as stepping stone in its early diagnosis.

At the outset, a child develops intricate features of speech like the phonetic, phonological, semantic, morphosyntactic and pragmatic with no obstacles. This progression happens naturally as children consistently get influenced by their environment.

Velum is a fibro muscular structure consisting of five muscles attached to the posterior portion of the hard palate. It effectively closes the communication between the nasopharynx and oropharynx by elevating the nasopharynx. The primary muscle involved in the elevation of the nasopharynx is the levator veli palatini which produces the superior and posterior movements of the velum. This movement causes the seal between the nasopharynx and oropharynx required for proper speech production.

During the speech, an increase in the length of the soft palate was discernible. This adjustment, known as Velar Stretch, is found in the majority of people and makes up for the fact that alone, velar motion is insufficient for forming a seal. The finest, most accurate way of measuring the various elements of the velum including pharyngeal depth, velar length, size of the entrance, degree of contact during closure and velar height, is by utilizing cephalometric x-rays. By analyzing these parameters, we can get an understanding of the structural integrity of the hardware and its capability to act properly when it comes to velar movement, velar stretch, and posterior wall movements and their transformations during growth and evolution.

Lateral cephalographs are accessible and commonly utilized in dentists' offices for orthodontic reasons. If Dyslalia can be identified using lateral cephalometry, it can easily be screened during the procedure. This would help to get a fast diagnosis of Dyslalia. Previous research conducted to evaluate velar extension in lateral cephalograms has been rare. This assessment intends to become the first to measure the stretch of the velar in various age ranges and further examine the figures to compare it to the prevalence and incidence of Dyslalia around the world in different age groups.

Very few researches in previous years have been done to measure velar stretch in lateral cephalograms. This assessment will be first of its kind to assess velar stretch in different age groups and further correlating the values with incidence and prevelance of the Dyslalia worldwide.

AIM

The aim of the study is to evaluate velar parameters while rest and phonation in different age groups.

OBJETIVES

1. To establish a possible co-relation between velar retraction & stigmatism type of Dyslalia defect in different age groups.

2. To assess age group of attainment of maximum velar retraction.

3. To assess usefulness of lateral cephalogram in evaluation of velar retraction.

1. Velum

It is the fibromuscular part of the palate that is attached to the posterior edge of the hard palate.[3] The soft palate plays a key role in velopharyngeal closure, which refers to the normal apposition of soft palate with posterior and lateral pharyngeal walls. It takes partin most of the oral functions, especially velopharyngeal closure which is related to the normal function of sucking, swallowing, and pronunciation.

In 1941 Michael Oldfield [4] of the general infirmary at Leeds England noted that the muscular elements of the soft palate apart from the uvular muscle consist essentially of four slings these are actually bilateral muscles which effect the sling like function through their common insertion into the tissues of the soft palate superiorly lay muscles like levator and tensor palatine and inferiorly lay palatoglossus and palatopharyngeus muscles.

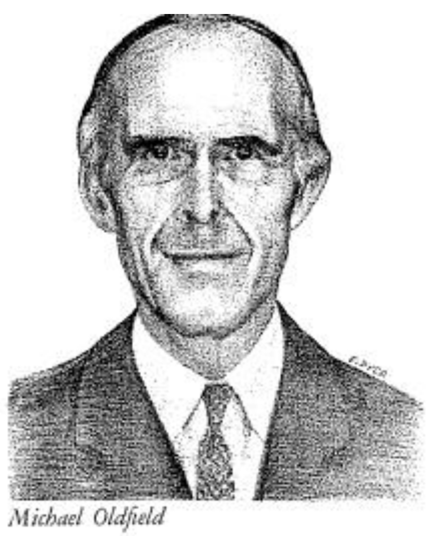


Figure 1 Michael Oldfield

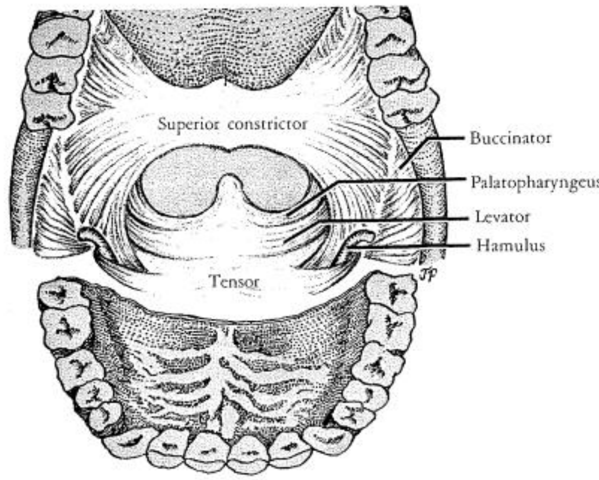


Figure 2 Muscle attachment of velar region

Gustavo Sanvenerorosselli of Milan, historical scholar who accumulated an extensive plastic surgery library reminded cleft specialists at the 1973 Copenhagen International Cleft Palate Congress that Leonardo Da Vinci understood the function of the soft palate in using vowels in speech and was cognizant of the varying levels attained by the palate during speech. The first true anatomical descriptions of normal anatomy of palate and pharynx were published by Von Luschka in Germany in 1868.(5)

Development of Velum

From the medial borders of the maxillary prominences, new outgrowth forms which later results in creating the shelves of the secondary palate.(6) These palatal shelves tend to grow in the downward direction beneath the tongue, and partially fill the nasal cavities. At about the ninth gestational week, these shelves extend, make contact, and fuse with each other above the tongue.

Fusion of palatal shelves requires alterations in the epithelium of the medial edges that begin prior to elevation. These alterations consist of cessation of cell division, which appears to be mediated through distinct underlying biochemical pathway, including a rise in cyclic AMP levels. There is also loss of some surface epithelial (peridermal) cells and production of extracellular surface substances, particularly glycoproteins that appear to enhance adhesion between the shelf edges as well as between the shelves and inferior margin of the nasal septum. The ultimate fate of these remaining epithelial cells is controversial. Some of them appear to undergo cell death and eventually are phagocytised, but recent studies indicate that many undergo direct transformation in mesenchymal cells. The fate of epithelial cells in the primary palate is also questionable. Some of the epithelial cells remain indefinitely in clusters (cell rests) along the fusion line. Eventually, most of the hard palate and all of the velum are formed from the secondary palate rather than primary palate.

Anatomy of Velum

Velum is a freely movable, muscular fold, attached from the posterior border of the hard palate.(Figure) It separates the nasopharynx from the oropharynx, and is often looked upon the crossroads between the food and air passages.(7) The soft palate has two surfaces and two borders, anterior and posterior and superior and inferior, respectively. The anterior surface is concave and is noticeable with median raphe. The posterior surface is convex, and is moving superiorly with the floor of the nasal cavity. The superior border is connected to the posterior border of the hard palate, combining each side with the pharynx. The inferior border is free and not attached with any borders rather bounds the pharyngeal isthmus. From the middle, there hangs a conical projection, called the uvula. Two curved fold membrane extend laterally and downwards, from both side of the base of the uvula. The anterior fold is called the palatoglossal arch or anterior pillar of faucets. It contains the palatoglossus muscle and reaches the side of the tongue at the junction of its oropharyngeal parts. This fold forms the lateral boundary of the oropharyngeal isthmus or isthmus of faucets. The posterior fold is called the palatopharyngeal arch or posterior pillar of faucets, which contains the palatopharyngeal muscle and forms the posterior boundary of the tonsillar fossa, merging it inferiorly with the lateral wall of pharynx.

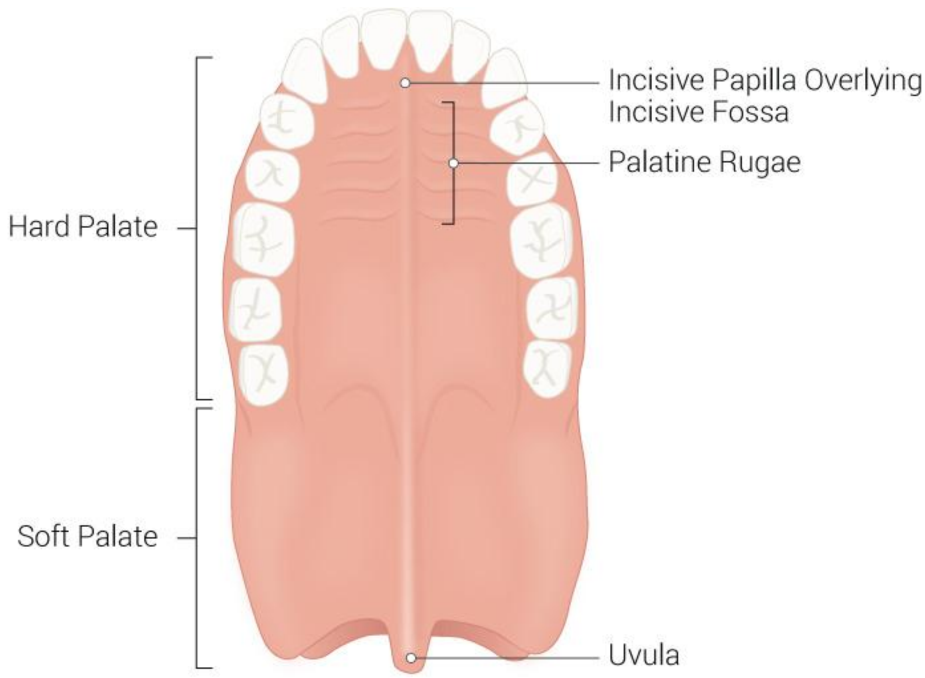


Figure 3 SHOWING SOFT PALATE

Muscles of the Velum[7]

1. Tensor palate (tensor veli palatine)
2. Levator palate (levator veli palatini)
3. Musculus uvulae
4. Palatoglossus
5. Palatopharyngeus

Tensor veli palatini

The tensor veli palatine (TVP) muscle attaches to the palatine aponeurosis from its origin at the medial pterygoid plate of the sphenoid. It functions to tense the soft palate during swallowing, preventing the entry of food into the nasopharynx. The TVP was viewed after removing the surrounding parapharyngeal fat. (Figure 4) The TVP surfaced from the inferior aspect of the Eustachian tube cartilage just like the LVP, only anterior to it. (Figure 4) (Figure 5) (Figure) When emerging, the TVP was flat while the LVP was tubular-shaped. The TVP ran down nearly vertically, wrapped around the hamulus, and turned into the aponeurosis, which went upward and joined the fascia in the midline.

Levator veli palatini

The levator veli palatine (LVP) muscle emerges from the eustachian tube and the petrous temporal bone before attaching to the palatine aponeurosis, this muscle functions to elevate the soft palate during swallowing to prevent the entry of food into the nasopharynx. The LVP was tubular-shaped when it came out from the inferior aspect of the Eustachian tube cartilage. (Figure 5) (Figure 6) After entering the soft palate, it became flat. It ran antero-inferiorly to the midline, distributed within the nasal side of the soft palate, and attached to the undersurface of the fascia and aponeurosis. The vertical distance from the top of palatopharyngeal arch to the LVP was 12.3 +/- 5.2 mm (range: 7.0–23.5 mm). (Figure 5)

Musculus uvulae

The musculus uvulae muscle derives from the palatine aponeurosis and the posterior nasal spine and attaches to the mucous membrane of the uvula. The musculus uvulae muscle functions to shorten the uvula. Ipsilateral contraction of the musculus uvulae muscle draws up the uvula on the same side.

Palatoglossus muscle

It arises from the palatine aponeurosis and travels inferiorly, anteriorly, and laterally to attach into the side of the tongue. The palatoglossus muscle (PG) functions to pull the soft palate towards the tongue and initiates the act of swallowing. The PG was a very thin muscle that made up the palatoglossal arch. (Figure 6) (Figure 7) Its mean width was 3.2 +/- 1.2 mm (2.0–5.0 mm). It came from the midline fibro-fatty layer and ran into the tongue base. The space between the PG and PP was the tonsil bed, which was covered by the superior constrictor muscle. All these structures are presented with a 3D illustration. (Figure 8)

Palatopharyngeus muscle

It emerges from the hard palate and the palatine aponeurosis and attaches to the superior border of the thyroid cartilage. The palatopharyngeus (PP) muscle tenses the soft palate and draws the pharynx superiorly and anteriorly during the act of swallowing. The palatopharyngeus muscle closes the laryngeal airway during swallowing to prevent the aspiration of food. The PP was a flat muscle. (Figure 3)(Figure 5) It emerged from the lateral pharyngeal wall and spread into the soft palate similar to the ribs of a fan. The medial part elongated to the midline and was embedded into the fibro-fatty layer, which made up the palatopharyngeal arch. The lateral part was steeper than the medial component, climbing the LVP. Its free margin also was embedded into the fascia over the LVP.

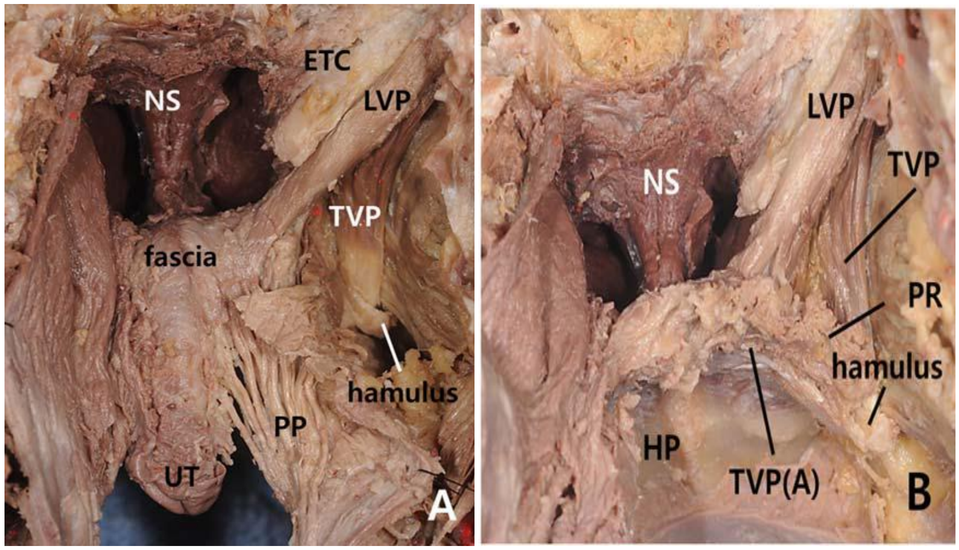


Figure 4 Posterior view of the soft palate after removal of parapharyngeal fat (A) and after removal of Palatopharyngeus and central part of soft palate.

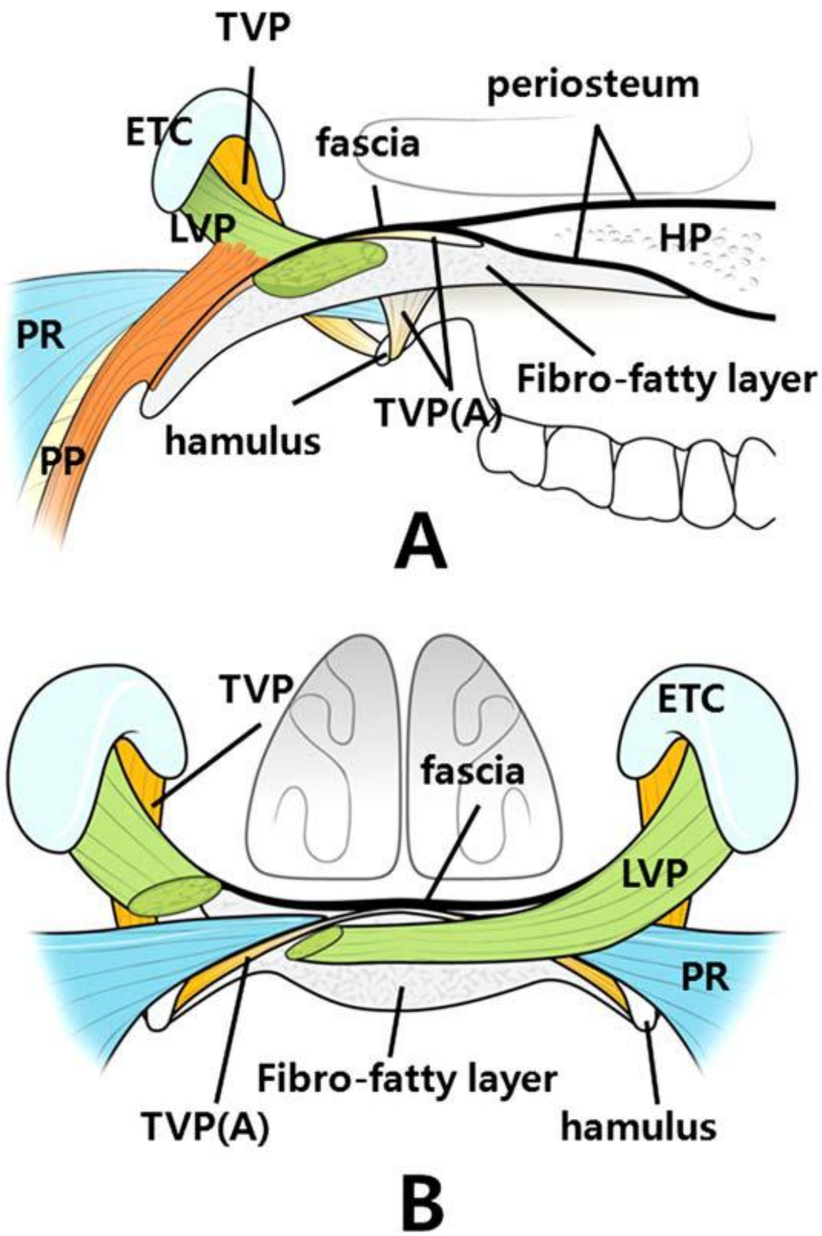


Figure 5 Schematic illustration of soft palate sagittal (A) and coronal (B) view

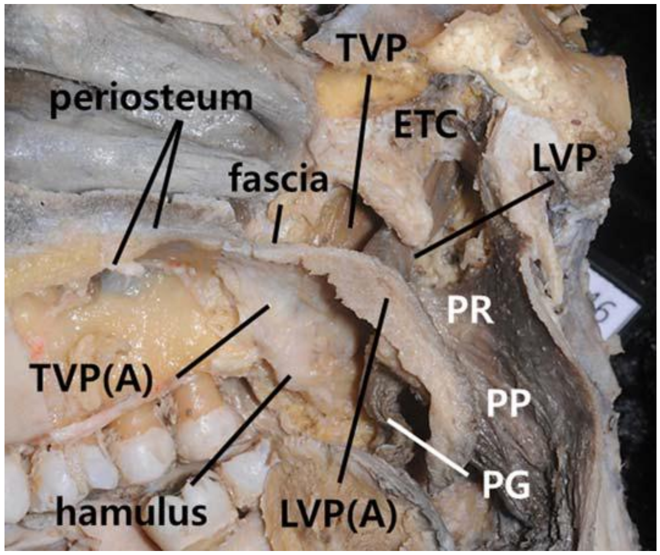


Figure 6 Sagittal view of the soft palate

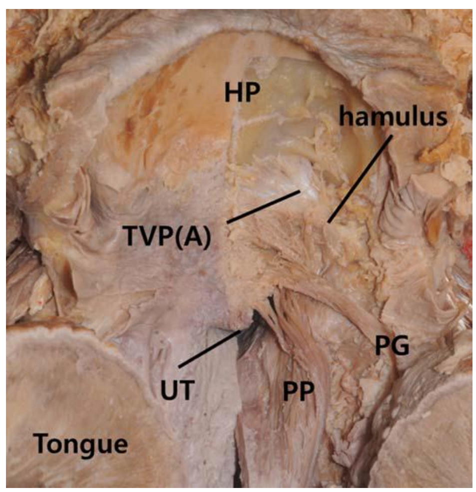


Figure 7 Oral view of the soft palate after removal of mucosa on the left side

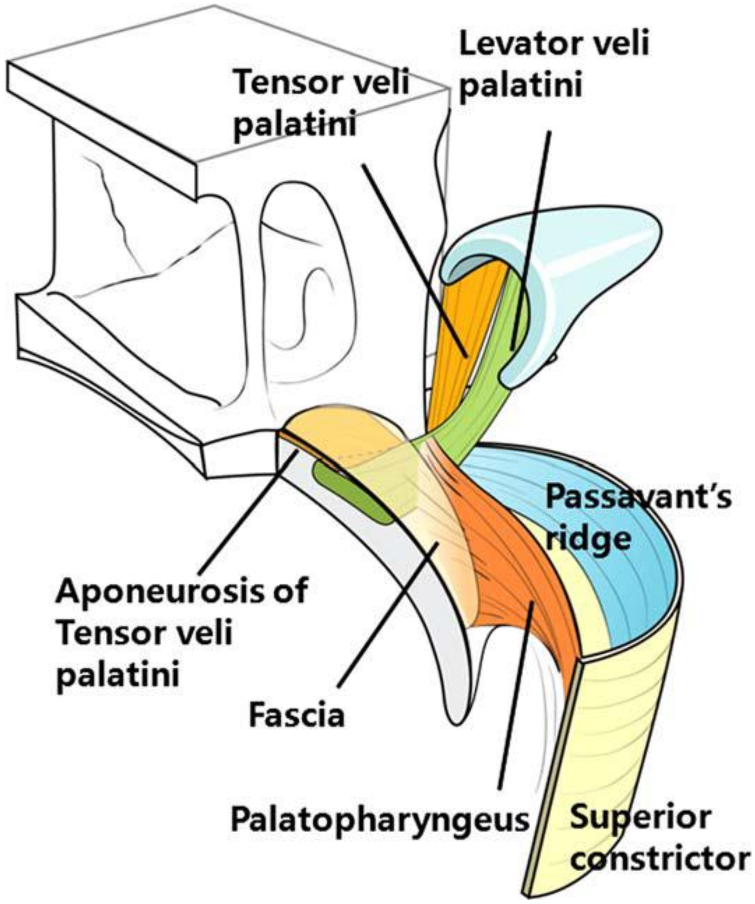


Figure 8 Three-dimensional illustration of the soft palate

ETC = Eustachian tube cartilage; HP=hard palate; LVP= levator veli palatini; NS=nasal septum; PR=Passavant's ridge; TVP=tensor veli palatini (A=aponeurosis); UT=uvula tip

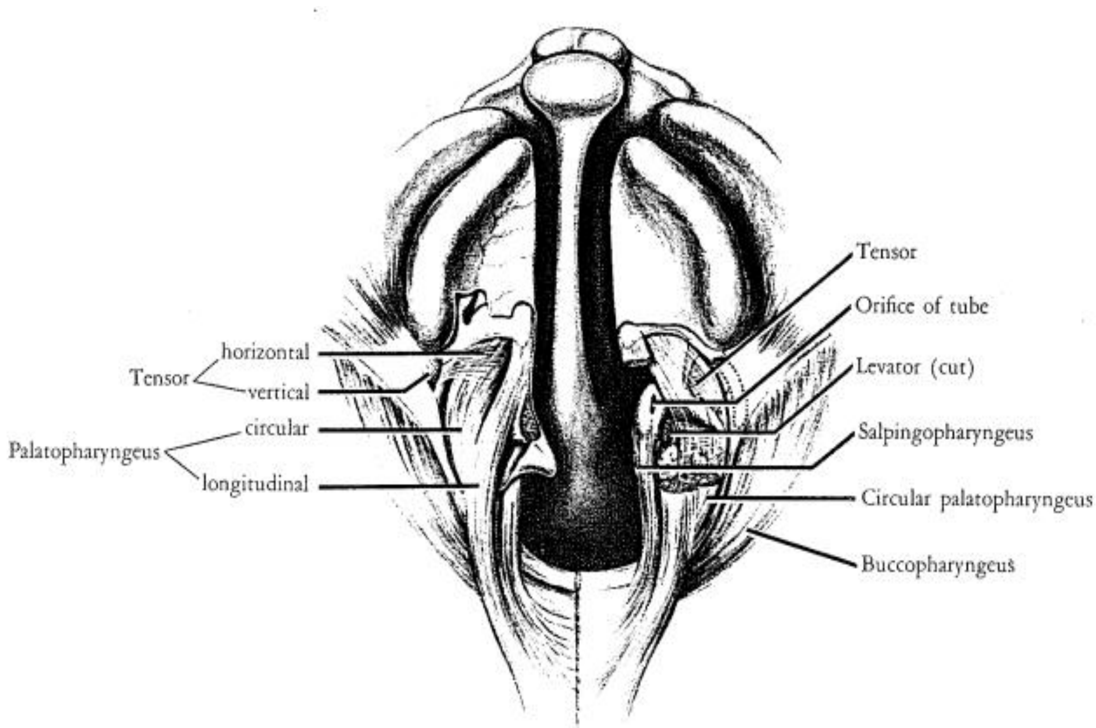


Figure 9 Diagram of the dissected soft palate from the oral aspect (4)

NERVE SUPPLY OF VELUM

1. Motor nerves: all muscles of the soft palate except the tensor veli palatine are supplied by the pharyngeal plexus. The fibers of this plexus are derived from the cranial part of the accessory nerve through the vagus. The tensor veli palatine is supplied by the mandibular nerve.

2. General sensory nerves are derived from:

a) The middle and posterior lesser palatine nerves, which are branches of the maxillary nerve through the pterygopalatine ganglion.

b) The glossopharyngeal nerve

3. Special sensory or gustatory nerves carrying taste sensations from the oral surface are contained in the lesser palatine nerves.

4. Secretomotor nerves are also contained in the lesser palatine nerves.

BLOOD SUPPLY OF VELUM

Arteries

1. Greater palatine branch of maxillary artery
2. Ascending palatine branch of facial artery
3. Palatine branch of ascending pharyngeal artery

Veins

They pass to the pterygoid and tonsillar plexuses of veins

Lymphatics

Drain into the upper deep cervical and retropharyngeal lymph node

VELUM DURING ACT OF SPEECH

During the production of oral speech, the velum moves in a superior and posterior direction until it closes firmly against the posterior pharyngeal wall. Only three sounds in the English language, /m/, /n/, /ng/, are produced with an open velopharyngeal port.[8] This superior and posterior movement is described as a ‘‘knee-like’’ action (white arrow on (Figure 10). The posterior pharyngeal wall moves forward slightly to assist in achieving contact.

In young children, the adenoid pad is positioned on the posterior pharyngeal wall in the area of natural velar contact. As a result, most children actually have veloadenoidal closure until the adenoids atrophy naturally with age. At the same time that the velum and posterior pharyngeal wall are in movement, the lateral pharyngeal walls move medially to close against the velum, or in some cases, just behind the velum. The relative contributions of the velopharyngeal structures differ among speakers, accounting for different patterns of velopharyngeal closure (i.e., coronal, sagittal, and circular).

When considering the entire velopharyngeal mechanism with its component structures, it should be realized that movement, and its sphincter like closure, must occur in three dimensions—the anterior-posterior dimension, horizontal dimension, and even vertical dimension. Complete velopharyngeal closure effectively seals off the nasal cavity from the oral cavity for the production of all oral speech phonemes. Closure is important for other activities that require positive oral pressure (i.e., singing, whistling, blowing, swallowing, gagging, and vomiting) and also for activities that require negative oral pressure (i.e., sucking and kissing).

There are three components to normal velopharyngeal function: anatomy, physiology, and learning. Of course, velopharyngeal closure requires normal velopharyngeal structure (anatomy) and normal velopharyngeal function (neurophysiology). What is often forgotten, however, is that the velopharyngeal valve is an articulator, just like the tongue and lips. As such, there is also a learned component to velopharyngeal function. The speaker must learn to use the valve correctly when attempting to produce oral speech sounds.

TYPES OF VELOPHARYNGEAL DYSFUNCTION

Velopharyngeal dysfunction (VPD) is a condition where the velopharyngeal valve does not close consistently and completely during the production of oral sounds. VPD is used as a broad term that encompasses all disorders (with various causes) that affect closure of the velopharyngeal valve.[9-14]

Velopharyngeal insufficiency (VPI) is often used to describe an anatomic or structural defect that prevents adequate velopharyngeal closure. Velopharyngeal insufficiency is the most common type of VPD. It includes a short or defective velum, which is common in children with a history of cleft palate, even after palate repair. In contrast, velopharyngeal incompetence (VPI) is used to refer to a neurophysiological disorder in which poor movement of the velopharyngeal structures results in incomplete velopharyngeal closure. Both types of VPI (velopharyngeal insufficiency or in competence) are medically based disorders that usually require physical management (surgery or a prosthetic device) for correction.

Finally, velopharyngeal mislearning refers to misarticulation, which results in an inappropriately open velopharyngeal valve during attempts to produce oral speech phonemes. This type of VPD requires speech therapy only. Although some professionals use these terms and other terms interchangeably, specificity in terminology is felt by other professionals to be very important. This is because the specific terminology stems from the difference in underlying causes. The different causes require different treatment and result in a different prognosis. [15-16]

CAUSES OF VELOPHARYNGEAL MISLEARNING

1. Faulty Articulation

During normal articulation development, some children learn to produce certain speech sounds incorrectly, resulting in a speech sound disorder. When an individual speech sound is produced inappropriately in the pharynx, the velopharyngeal valve will be open. This results in phoneme-specific nasal resonance and/or nasal air emission, because the nasality occurs only on that particular misarticulated speech sound or group of sounds. A common misarticulation is the substitution of a pharyngeal fricative or a posterior nasal fricative for sibilant sounds (s, z, t, d), particularly /s/ and /z/. Due to the way these sounds are produced, there is nasal emission with production. Other individuals will nasalize the vowel /i/ due to an abnormally high tongue position that restricts sound from entering the oral cavity.

In conversation, individuals with phoneme-specific nasality often sound similar to those with VPI (velopharyngeal insufficiency or incompetence). However, unlike those with

VPI, these individuals are not candidates for surgical or prosthetic intervention. Instead, speech therapy will be effective in correcting the abnormal articulation placement.

2. Compensatory Speech Productions

If there is significant VPI during normal speech development, many children learn to compensate for the lack of intraoral pressure by learning to produce sounds at the level of the glottis or in the pharynx (e.g., glottal stops, pharyngeal plosives, and pharyngeal fricatives). When the VPI is corrected, this pattern of articulation persists because changing the structure does not change the pattern of articulation. As a result, there may still be hyper nasality and nasal emission due to the way these sounds are produced. Postoperative speech therapy is very important to help the individual to eliminate compensatory articulation productions and learn to produce sound with normal oral placement.

3. Lack Of Auditory Feedback

Individuals with severe hearing loss or deafness usually demonstrate abnormal resonance due to the inability to monitor resonance. The velopharyngeal valve may close inappropriately on nasal phonemes and open on oral phonemes, causing hypernasality, hyponasality, or mixed resonance. In addition, cul-de-sac resonances common in individuals who are deaf due to retraction of the tongue and deflection of the epiglottis toward the pharyngeal wall.

Type Of Velopharyngeal Dysfunction: Implications For Treatment And Prognosis

Why should we bother to distinguish velopharyngeal insufficiency from velopharyngeal incompetence or from velopharyngeal mislearning? The reason is that the treatment and the prognosis are different for these different categories of velopharyngeal dysfunction. Therefore, differential diagnosis by a speech-language pathologist is very important so that the individual receives appropriate treatment.

Because velopharyngeal insufficiency is due to abnormal structure, it can only be corrected by physical management through surgery or an obturator. Speech therapy cannot correct or improve hypernasality or nasal emission as a result of abnormal structure. Once the structure is corrected through physical management, speech therapy is effective in correcting compensatory articulation productions that remain. With this type of VPI, the prognosis is usually very good for normal speech following appropriate treatment.

When there is a neurophysiological etiology causing velopharyngeal incompetence, some would argue that speech therapy may be effective in improving the nasality, although the literature does not support this. These individuals can sometimes benefit from a palate lift and, in some cases, even a surgery to partially close the velopharyngeal valve (e.g., a pharyngeal flap).

This will usually improve speech and resonance considerably, but not totally correct it. Finally, if the abnormal nasality is due to faulty articulation, speech therapy is the appropriate method of surgery. Surgery is not indicated. The prognosis for correction is excellent if the appropriate therapy techniques are used.

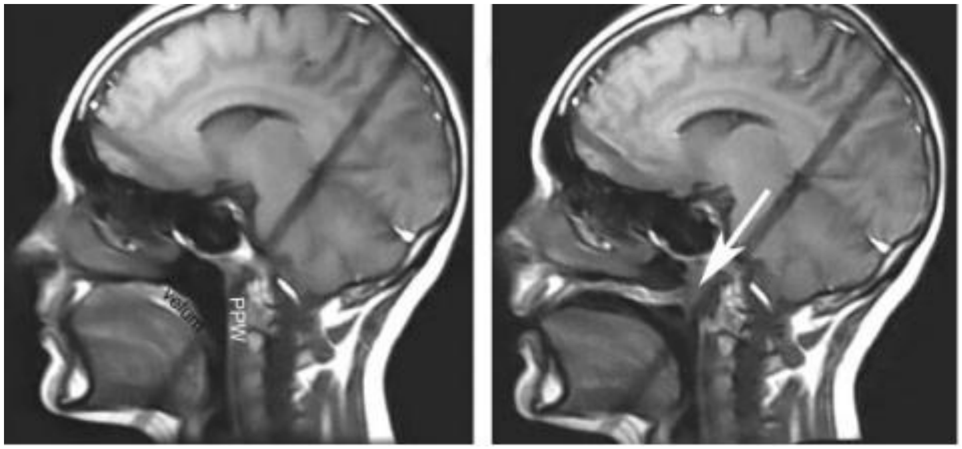


Figure 10 Midsagittal magnetic resonance imaging of velopharyngeal mechanism at rest (A) and during speech production (B). The white arrow is pointing at the velar eminence during elevation. (PPW - Posterior Pharyngeal Wall)

Velar stretch

Velar component movement is created primarily by the action of levator veli palatini muscle, while palatoglossus and palatopharyngeus muscles control the fine- tuning of velar position, and the paired musculus uvulae help in velar stretch. [17]

2. Dyslalia

According to the "Dictionary of Terms Dealing with speech after defects by Samuel B. Robbins and Sara M. Stinch field, dyslalia is "functional or organic defects of articulation dependent upon malformation or imperfect innervation of the tongue, soft palate, and other organs of articulation"

TYPES OF DYSLALIA

1. Paralalia

The first group of speech defects and defective studied under the general heading of dyslaliais that of Paralalia. According to Dictionary of Terms dealing with disorders of Speech, Paralalia is defined as a form of dyslalia characterized by the production of a distinctly different sound from that desired, or the constant substitution of one letter for another.

2. Sigmatism

In the sigmatism group, defects were not analyzed according to substitutions, but were classified as lateral and frontal. Lateral sigmatism is defined as a form of sigmatism characterized by the expulsion of a large amount of air from one side of ones mouth in using‘s’ sounds in speaking, and frontal sigmatism as a form of sigmatism characterized by substitution of ‘surd th’ for ‘s’ & ‘sonant th’ for ‘s’.

3. Urahiscolalia

A form of dyslalia characterized "by a thick, inarticulate form of breathy speech, in which all sounds except nasal sounds become modified, and in which explosives and vowels become nasal sounds. Uraniscolalia is understood to refer to defects due to cleft palate and hare lip.

4. Barbaralalia

Barbaralalia is defined as “a form of dyslalia due to language conflict and characterized "by the pronunciation of an english sound as it would be pronounced in some foreign language spoken by the speaker.

5. Dyslaliacophica

Dyslaliacophica is a combination of functional or organic defects of articulation dependent upon loss of hearing.

6. Dysphonia

Dysphonia is defined as, any defect of voice due to morbid condition of the larynx or it’s immediate innervation, to defective respiration, or to anomalies in the resonance cavities of the throat, mouth and nose.

7. Dyslalia organic

Dyslalia organica has been interpreted as referring to speech defects due to abnormalities of the speech mechanism other than cleft palate and hare lip.

8. Spasmophemia

Spasmophemia is defined as a form of parasigmatism characterized by the expulsion of a large amount of air from both sides of one's mouth, in using s sounds in speaking.

3. <u>Lateral Cephalograph Radiographs</u>

Lateral cephalometric radiographs are important in growth analysis, diagnosis, treatment planning, therapy monitoring, and evaluation of treatment outcome. Digital dental radiography is used in dental office today for the acquisition, measurement, and analysis of cephalometric images.

A lateral cephalometric radiographs is needed routinely. Lateral cephalograms have two purposes: (1) they reveal details of skeletal and dental relationships that cannot be observed in other ways, and (2) they allow a precise evaluation of response to treatment. In many instances, an adequate orthodontic diagnosis can be made without a cephalometric radiograph; however, accurate assessment of a patient'sresponse to treatment is practically impossible without comparing cephalometric films before, during and after treatment. For this reason, lateral cephalometric films are needed even for patients whose dental and skeletal relationship seems perfectly straight forward (e.g., class I crowding problems).Treating skeletal malocclusion without cephalometric evaluation might lead to serious error.

USES OF CEPHALOGRAMS

Cephalometry has established itself as one of the pillars of comprehensive orthodontic diagnosis. It is also a valuable tool in treatment planning and follow up of patients undergoing orthodontic treatment. The following are some of the applications of cephalometrics in orthodontics.

Cephalometric help in orthodontic diagnosis by enabling the study of skeletal, dental and soft tissue structures of the cranio-facial region**.** It helps in classification of the skeletal and dental abnormalities and also helps in establishing facial type.

Cephalometric helps in planning treatment for an individual. It helps in evaluation of the treatment results by quantifying the changes brought about by treatment. Cephalometric helps in predicting the growth related changes and changes associated with surgical treatment.

FACTOR AFFECTING CEPHALOMETRIC RADIOGRAPHS

Patient positioning and X-ray tube head settings are the two most critical factors in consistently producing cephalometric images of high diagnostic quality. Generally, patients are positioned within the cephalostat using adjustable bilateral ear rods placed within each auditory meatus, usually while the patient is standing. The midsagittal plane of the patient is vertical and perpendicular to the X-ray beam. The patient's Frankfort plane is oriented parallel to the floor. Positioning for the PA cephalogram is identical to that for the lateral cephalogram except that the patient is rotated 90 degrees, i.e. facing the film.[18]

RADIOGRAPHIC MAGNIFICATION

The x-ray emanating from the source have a divergent pattern, there is a variation in the amount of magnification of the object in any radiograph. To reduce the magnification in lateral cephalometric radiographs, one should increase the distance between the source of x-ray and the object to be radiographed in order to take advantage of the central beam, which is flatter, and also decrease the distance between the object and the radiographic film. It is recommended a distance of 152.4 cm between the x-ray source and the sagittal plane, considering that increasing the distance would result in loss of penetration of rays. According to Weens magnification of craniofacial structures varies from almost 0% upto 24% in objects close to the film or objects in the exact center of the rays. This magnification is not constant for all possible sagittal plane of patient. Structures located closer to the film will present lower magnification comparing to those closer to the rays. As mentioned earlier, another variable, considering the magnification factor, would be the distance between the midsagittal plane of the individual and the film. To minimize variations between different patients and obtain consistent measurements in an individual's overtime, it is recommended to maintain constant this distance. An average distance of 15 cm is often used; although it would be ideal to position the frame as close to the patient's head as possible to reduce the magnification[19]

PATIENT POSITIONING[20]

The lateral cephalometric radiograph displays numerous cranial, facial, and oral anatomic structures imaged from the lateral aspect. Additionally, structural points of reference leading to angular and distance measurements may be visualized to assess growth patterns.

The visualization of the structures in the radiographic image is dependent on proper alignment of the X-ray beam and the patient. Proper alignment of the X-ray beam relative to the cephalostat may be evaluated by exposing a test film of the head-stabilizing ear rods without a patient positioned in the cephalostat. Proper alignment is assured if the radiopaque circle representing the film-side ear rod is reasonably centered within the image of the beam-side ear rod. This helps to ensure that the midsagittal plane will be perpendicular to the x-ray beam once the patient is placed within the ear rods.

An 8x 10- inch film cassette/digital sensor equipped with the appropriate film and intensifying screens is placed either horizontally or vertically in the cephalostat cassette holder. The proper x-ray beam collimator must be selected depending on the film cassette's orientation. The anterior border of the film should be placed so that the soft tissue outline of the nose will be captured on the film image. The patient is then positioned within the cephalostat ear rod, exerting moderate pressure on the external auditory meatus. Excessive horizontal movement of the head within the cephalostat will create variations in beam-object alignment, thus causing inaccurate image analysis and comparison when cephalometric superimpositions are made.

The patient's Frankfort plane is placed parallel to the floor. Some X-ray technicians prefer to place the patient's canthomeatal line upward 10 degree relative to the floor. Either method of placement will result in the patient's occlusal plane being in the proper downward orientations. A locking nasal positioner is then secured against the bridge of the patient's nose to eliminate rotation around the car rod in the sagittal plane and for future reference in subsequent exposures. As this point the film cassette is moved to the desired distance from the patient's midsagittal plane. The central ray of the x-ray beam will enter and exit the patient near the horizontal axis of the auditory meatus.

The amount of x-ray energy necessary to penetrate certain dense areas of the human skull will, in most cases, "burn out” the soft tissue of the nose, lips, and chin.thus resulting in excessive density in those areas. Imaging the patient's soft tissue profile without the loss of bony details may be accomplished by attenuating or blocking out some of the beam's energy with a soft tissue shield. This shield is often a wedge of aluminum placed on the x-ray film cassette so that it primarily covers the area behind the patient's soft tissue profile. In some machine, a small aluminum attenuator is placed within the x-ray beam inside the tube-head, which has the additional benefits of reducing the radiation dose to the soft tissues and producing a less-distinct wedge image than when the shield is placed in direct contact with the film cassette. Care must always be taken not to reduce the beam energy to the point of obliterating the opaque image of the nasal bone, anterior nasal spine, and the long axis of the maxillary and mandibular incisors located near the shielded area.

Once properly positioned, the patient should be instructed to close to centric position, swallow, and hold the body of the tongue in the posterior area of the soft palate. This will reduce the radiolucent band in the resulting image representing the pharyngeal air space commonly superimposed across the angle of the mandible. The patient should then be instructed to remain still throughout the exposure.

Verma SK, Maheshwari S, Gautam SN, KC Prabhat, Kumar S (2012)[(21)]reviewed the Frankfort horizontal is a useful compromise for studying skulls but not for orienting the natural head position (NHP) in the living because it is normally distributed around a true extracranial horizontal. Nonetheless, orthodontists dealing with living subjects, rather than inert crania, have used this Frankfort horizontal faithfully in cephalometry. Because the cant or inclination of all intracranial reference lines is subjected to biologic variation, they are unsuitable for meaningful cephalometric analysis. Registration of head posture in its natural position has the advantage that an extracranial vertical or a horizontal perpendicular to that vertical can be used as the reference line for the cephalometric analysis.

Shetty D, Bagga DK, Goyal S, Sharma (2013)[22]studied on a cephalometric study of various horizontal reference planes in natural head position. For the present study, 100 subjects (50 males and 50 females) were selected between the age group of 17-25 years having pleasing profile with competent lips with angles class I molar relationship and normal overjet and overbite with no history of taking any form of orthodontic treatment. The study concluded that among all the reference plane studied, the Frankfort horizontal plane was closest to the true horizontal and thus could be recommended as a reference plane, when radiographs were not recorded in natural head position.

DIGITAL IMAGING TECHNOLOGY

Technical advances in computer science have made it possible to perform cephalometric tracing both through the use of digitizers and directly on screen displayed digital images. First-generation computer-based analysis systems used digitizer pads for tracing conventional cephalometric films and software programs to compute the measurements, whereas second-generation systems use scanners or digital cameras to export cephalometric images to measurement programs.

Recently, third-generation systems have been introduced that transmit digital radiographs directly to a computer database through the use of photostimulable phosphor plates, charge-coupled device receptors, or direct digital systems. The use of direct digital images offers several advantages, such as instant image acquisition, reduction of radiation dose, facilitated image enhancement and archiving, elimination oftechnique-sensitive developing processes, and facilitated image sharing. Both digital radiography and conversion of conventional analogue film to a digital format require less storage space than conventional cephalometric film. Digital archiving is also a valuable method for overcoming the problem of film deterioration, which has been a major source of information loss in craniofacial biology. Several drawbacks such as the inability to perform structural superimposition and the need for a digital cephalometric radiographic machine and a software program are also present. With the rapid evolution of computer radiography, digital tracing has slowly replaced the manual tracing methods. Three techniques are commonly reported & the first uses digitizer pads for tracing conventional cephalometric films and software programs to compute the measurements; the second uses scanners or digital cameras to export cephalometric images to measurement programs; and the third transmits digital radiographs directly to a computer database. The use of both digital radiography and conversion of manual film to a digital format offers several advantages- it is easy to use, allows several analyses to be performed at a time, promises convenience when generating treatment predictions, takes up less storage space, allows superimposition of images, provides the option to manipulate the size and contrast of the image and provides the ability to archive and improve access to images to overcome the problem of film deterioration, which has been a major source of information loss in craniofacial biology. Moreover, patients benefit from reduced radiation dose and elimination of chemicals and associated environmental hazards if a direct digital cephalograph is used for image capture. However, several drawbacks are also present, such as difficulty in landmark identification related to the 2D representation of a 3D structure, superimposition of bilateral structures and the need for a digital cephalometric radiographic machine as well as a software program. Furthermore, the quality of digital images is affected by their resolution, pixel size, shades of grey (bit)and compression format.[23] For digital cephalometry to be a better tool in clinical orthodontics, the cephalometric analysis, represented by widely used linear and angular measurements, must be as a comparable and reliable as it is on a conventional radiographic film.[24]

FACTORS AFFECTING DIGITAL IMAGE QUALITY

Image quality is affected by a number of factors, beginning with the acquisition process and device and including the manner in which images are displayed. In digital systems, the functions of acquisition and display are clearly separable, so that the evaluation and optimization of image quality can take place at both ends of this imaging continuum. The analysis of image quality also depends on the particular type of imaging task. Digital radiography is used in a wide variety of imaging tasks (eg, chest, musculoskeletal), but there are basic image-quality parameters that can be defined that are applicable to all of these tasks[25]

1. MATRIX SIZE AND DISPLAY SIZE

Soft-copy displays should render images with sufficient pixel density to allow viewing of the whole image with sufficient spatial detail at a normal viewing distance of approximately 30 to 60 cm (with eyeglasses specifically selected for this distance when required). Matrix size should be as close to the for-processing image data as possible or attainable with magnification. A 5-megapixel (MP) (2,048 × 2,560 pixels) monitor (usually in portrait mode with a diagonal dimension of 54 cm [21 in)exceeds the matrix size stipulated by the ACR's standard of a resolution of at least 2.5 Ip/mm at the detector plane when acquiring a 35 x 43 cm image (equivalent to 14 x 17in), and thus is sufficient for viewing all types of computed radiographic and digital radiographic images in a single view. Note that the US Food and Drug Administration recommends that only monitors that have been approved for digital mammography be used for interpreting digital mammography images. A 1-MP (1,024 x 1,280 pixels), 2- MP (1,200 x 1,600 pixels), or 3-MP (1,536 × 2,048 pixels) monitor will not permit full simultaneous viewing of 35 x 43 cm images at a detector plane resolution of 2.51p/mm. For those images, zooming and roaming display functions are required to achieve a correspondence between the detector element matrix and the display pixel matrix so that the resolution of the display monitor does not limit the resolution of the partially displayed image. This is true for any size image for which the detector element matrix size exceeds the display pixel matrix size.(25)

2. LUMINANCE AND CONTRAST

The luminance of a display can affect image quality significantly, so the appropriate range of luminance should be maintained. The ratio of maximum luminance to minimum luminance of a display device for images (other than for mammography) should be at least 100. The maximum luminance of gray-scale monitors used for viewing digital conventional radiographs should be at least 200 cd/m^2. Smaller ranges could lead to inadequate levels of contrast in displayed images and larger values could lead to poor visualization of details at the extremes of the luminance range because of the limited range of the contrast sensitivity of the human being. The contribution of ambient light reflected from the display surface should be included in luminance measurement considerations, because some level of ambient light is always present. Luminance should be as uniform as possible across the entire display. The contrast response of a display should comply with the AAPM Task Group 18 recommendations. A high display contrast ratio with a low minimum luminance level (0.5 cd/m^2) is most desirable. Contrast response should not deviate from the DICOM Gray scale Standard Display Function (GSDF) contrast values by more than 10%. [25]

3. BIT DEPTH

It is necessary for a soft-copy display device to render image details with sufficient luminance quantification to prevent the loss of contrast details or the appearance of contour artifacts. Thus, a minimum of 8-bit luminance resolution (bit depth) is required. Nine-bit resolution or higher is recommended if the for-processing image data are greater than 8-bit. In general, the higher the luminance ratio of the display, the larger the bit-depth resolution that is recommended.[25]

4. DISPLAY CALIBRATION

All monitors and corresponding video graphics cards used for primary diagnosis or for image adjustment and evaluation (e.g., a technologist review monitor)must provide a means to be calibrated to and conform to the current DICOM GSDF perceptual linearization methods. The intent of the DICOM GSDF is to allow images transferred using the DICOM standard to be displayed on any DICOM-compatible display device with a consistent gray-scale appearance. Additional factors to consider when characterizing a soft-copy display for interpreting medical images include the modulation transfer function and noise. The modulation transfer function at the Nyquist frequency of the display should be greater than 35%, as recommended by the AAPM Task Group 18documents. A display device also should not add more than a third of the noise of atypical image, limiting the display relative noise to 0.6% to 0.8%. Desirable display calibration features include remote performance monitoring, calibration, and quality control. Monitor set matching of contrast ratio, brightness, and color are generally accomplished with the DICOM GSDF, although color does not have a standard calibration method to date.[(25)]

5. GLARE AND REFLECTIONS

Veiling glare or the spread of light within the display can reduce contrast, so the glare ratio should be greater than 400 for primary displays. Reflections from ambient light sources should be kept at a minimum. Indirect and backlight incandescent lights with dimmer switches rather than fluorescent lights are recommended. Light-colored clothing and laboratory coats can increase reflections and glare. The intrinsic minimum luminance of a device should not be smaller than the ambient luminance (minimum luminance should be at least 2.5 times ambientlight). Cathode ray tube (CRT) displays typically have antiglare coatings that can help reduce these effects, but not eliminate them. Protective shields on liquid crystal displays (LCDs) add to reflections and should not be used if possible. [(25)]

6. COLOUR TINT AND COLOUR DISPLAYS

Both monochrome and colour displays have a colour tint that is a function of where the manufacturer sets the white point. The tint of the display can affect the comfort of the user. The color tint of the display (blue, gray, yellow, etc.) is based on user preference but should be uniform across the display area, and monitor pairs should be matched from the same manufacturing batch. Currently, most colour displays have lower luminance and thus lower contrast ratios than monochrome displays and are generally not recommended for viewing certain radiographic modalities (chest, bone, and mammography). There are currently no accepted standards or guidelines available for calibrating color displays when viewing gray- scale radiographic images, so care should be taken. The DICOM GSDF can be applied to color displays but does not fully address this issue of calibration of color displays.[25]

TRACING TECHNIQUE

Before any attempts are made to trace a cephalometric head film, the clinician should become thoroughly familiar with the gross anatomy of the head, in particular the bony components of the cranium and face. Access to a dry skull also is helpful initially as an aid in identifying the various bony landmarks.

It is important to recognize that a two-dimensional cephalogram represents a three-dimensional object and that bilateral structures are projected onto the film. The technician should be able to distinguish bilateral structures and trace them in most instances from left-to-right outline. The outline will not be perfectly superimposed due to facial asymmetry, greater magnification in the image on the side the skull farthest from the film, and imperfect positioning of the patient in the cephalostat. By convention, bilateral structures (e.g., the rami and inferior borders of the mandible) are first traced independently. A broken line is then drawn by visual approximation to represent the average of these lines.

All bilateral landmarks that are present are located on the "average" outline of a specific bone such as the mandible.[20]

GENERAL CONSIDERATIONS FOR TRACING

Start by placing the cephalogram on the view box with the patient's image facing to the right. (By convention, the lateral head plate faces right for most orthodontic analysis) Tape the four corners of the radiographs to the view box. With a fine fell-tipped black pen, draw three crosses on the radiograph, two within the cranium and one over the area of the cervical vertebrae. These registration crosses allow for reorienting the acetate tracing on the film for later verification or in the event the film becomes displaced during the tracing procedure, a nor infrequent occurence. Next, place the matte acetate film over the radiographs and tape it securely to the radiograph and the view box. (The shiny side of the acetate film isplaced down, against the radiograph) After firmly affixing the acetate film trace the three registration crosses, print the patient's name, record number, age in years and months, the date the cephalogram was taken, and your name in the bottom left hand corner of the acetate tracing. Use smooth continuous pressure on the pencil whenever possible, trace image lines without stopping and/or lifting the pencil from the acetate film. Avoid erasures. Consult dental casts when outlining molar and incisor teeth taking care to depict left and right teeth.

The faint shadow lines in the outline of the soft tissue profile (e.g, anterior nasal spine, nasion) can be more readily visualised by masking the light, radiopaque areas of the radiograph with one or more sheets of black cardboard paper. For certain applications such as serial or post treatment studies, it is helpful to trace as much anatomy as possible in the areas of the skull base, palate, and mandible (including, when visible, the mandibular canal) to provide a better basis for super positioning serial radiographs. [20]

Paixao MB, Sobral MC, Vogel CJ, TelmaAraujo T.M.D (2010)[26]studied on comparative study between manual and digital cephalometric tracing using Dolphin imaging software with lateral radiographs. The study sample consisted of 50 lateral cephalometric radiographs. One properly calibrated examiner performed 50 manual and 50 digital cephalometric tracing using eight angular measurements [FMA, IMPA, SNA, SNB, ANB, 1.NA, 1.NB, Y-Axis] and six linear measurements [1-NA, 1-NB, Co-Gn, Co-A, E Line -Lower lip and LAFH]. Results were assessed using student's t-test. The results showed no statistically significant differences in any of the assessed measurements ($p > 0.05$).

Agarwal N, Bagga DK, Sharma P (2011)[24] took up a comparative study of cephalometric measurements with digital versus manual methods. The study include digital photographs of 32 cephalograms were imported into the Nemotec digital imaging software. Digital measurements of 41 hard and soft tissue variables generated by the software were compared to those obtained by manual tracings. Reproducibility for each method was assessed using pearson’s correlation coefficients by repeating measurements of all radiographs at an interval of 3 months. A paired t-test was used to detect differences between the manual and digital method. The study showed digital measurements obtained with the Namotec digital imaging software using digital photographs of analogs cephalograms were found to be reproducible and comparable to the manual method for most of the variables used in clinical practice except a few which could not be measured accurately with the digital method.

GhoneimaA, Albarakati S, Baysal A, Uysal T and Kula K(2012)[27] conducted a study on Measurements from conventional, digital and computer derived cephalograms. The study sample consisted of lateral cephalometric radiographs of 30 patients that were manually traced. The radiographs were subsequently scanned and traced using Dolphin imaging software 11. The CT- created lateral cephalograms were also traced using the same software. Sixteen (10 angular and 6 linear) measurements were performed. Cephalometric measurements obtained from conventional, digital and CT-created cephalograms were statistically compared using repeated measures analysis of variance (ANOVA). The study showed there are statistically- significant differences in measurements produced using a traditional manual analysis, a direct digital analysis or a 3D CT-derived cephalometric analysis of orthodontic patients. These differences are, on average, small but because of individual variation, may be of considerable clinical significance in some patients.

Navarro RDL, Oltramari-navarro PVP, Fernandes TMEF, et al. (2013) [28] studied on comparison of manual, digital and lateral CBCT cephalometric analyses. The study material consist of conventional pretreatment lateral cephalograms and cone beam computed tomography (CBCT) scans from 50 subjects from a radiological design were selected in order to test the three method: manual tracing (MT), digitized lateral cephalograms (DLC), and lateral cephalograms from CBCT(LC-CBCT).The lateral cephalograms were manually analyzed through the Dolphin imaging 11.0 software. Twenty measurements were performed under the same conditions, and retraced after a 30 days period. Paired t-tests and the Dahlberg formula were used to evaluate the intra-examiner errors. The Pearson's correlation coefficient and one-way analysis of variance (ANOVA) tests were used to compare the differences between the methods. The result showed that all evaluated methodologies are reliable and valid for scientific research, however, the method used in the lateral cephalograms from the CBCT proved the most reliable.

Mahto RK, kharbandaOP, Duggal R, Sardana HIK (2016) [29] took up comparison of cephalometric measurements obtained from two computerized cephalometric software's with manual tracing. The study sample consisted of pretreatment lateral cephalograms that were selected from the archives of a postgraduate orthodontic clinic. The digital images of each cephalogram were imported directly into softwares Dolphin and AutoCEPH for onscreen digitization. While for manual tracing digital images were printed using a compatible X-ray printer. After images were standardized and calibrated 34 commonly used anatomical landmarks were plotted on each cephalogram. These landmarks were then utilized to evaluate 35 cephalometric parameters. Intraclass correlation coefficient (IC) was used to determine both intrarater reliability for repeated measurements and agreements between linear and angular measurements obtained from all parameters while comparing three methods, i.e., manual tracing versus AutoCEPH, manual tracing versus Dolphin and AutoCEPH versus Dolphin. The study concluded that a high level of agreement (ICC<0.9) for cephalometric measurements was obtained from both the computerized software Dolphin and AutoCEPH in comparison with manual tracing.

Subtelny J. Daniel et al.(1956) (30) studied in thirty-five "normal" patients by means of x-ray. Twenty children, ranging from four to twelve years of age, were assessed to determine the anatomic and functional changes resulting from the surgical removal of adenoid tissue. Cephalometric roentgenograms and laminagrams were taken on each of these subjects, both before and after surgical removal of adenoid tissue. The remaining15 subjects, on whom longitudinal serial x-rays were available over varying periods of time, were studied to evaluate the growth features of the adenoid tissue and of the surrounding structures.

Subtelny J. Daniel (1957) (31) illustrated for the time on a longitudinal basis, the dimension of nasopharyngeal space changes as a function of growth. The measurement from the posterior nasal spine of the hard palate to the roof of the nasopharynx revealed that there was a progressive increase in depth and height of the nasopharynx as a result of growth.

Graber et al. (1959) (32) evaluated in their study of 42 normal adults, and results showed that "there is a significant increase in length of the palate from rest to the functional position." It was the first study to report the phenomenon of velar stretch.

Moll L. K. et. al. (1964) (33) designed the study to provide a preliminary test of a new concept of velar activity during speech production. It was hypothesized that velar elevation represents part of a preparatory activity for utterance which occurs prior to the beginning of any “phonation.”

Bzoch R. Kenneth (1968) [34]; their study consisted of five normal adult speakers, and found an average increase in length of 16.28 mm or 49% from rest to the functional position. Cinefluorographic films were taken of five young adult subjects producing utterances of repeated CV syllable sets in varying order. The findings of this study showed that the velar position for the syllables with the vowel /a/ is slightly lower than for syllables with either /i/ or /u/; and the velar dimensions do not vary as a function of the order of syllable sets in an utterance sequence, and the velopharyngeal port remains sealed throughout the production of CV syllable sets under the conditions of this study.

In a study by **Pruzansky et al. (1969)** [35] 110 patients were included with congenital palatopharyngeal incompetence and showed an increase in intrinsic length of velum during velopharyngeal valving." They coined the term "velar stretch" to designate this increase in intrinsic length.

Simpson et al. (1972) [36] reported that adults showed 20% stretch, the 8 year old children had 4.82% stretch, and the 10 year old children had 11.93% stretch. From this, it could be inferred that total velar stretch does increase with age. For both the eight-year-old group and the 10-year-old group, the correlation between the amount of stretch and need ratio was significant.

Weinberg et al. (1976) [37] in their study evaluated velar stretch in 20 eight-year-old children and20, 10-year-old children, with both groups having an equal number of boys and girls. For the total group, a significant increase in velar length was obtained during the production of both /u/ and /s/. The mean stretch for the /u/ was 11.22%, and the mean stretch for /s/ was 8.375%. However, subjects were able to obtain adequate closure without any velar stretch.

In another study by **SIMPSON K. ROBERT et al. (1980)** [38] Velar stretch was evaluated in 20 normal adolescents using cephalometric x-rays during the production of /s/. The behaviors of both the anterior and posterior portions and the total velum were evaluated using radio opaque markers. Velar stretch was found in each of the subjects with the average stretch (15.19%) and was more significant than the amount reported for 10-year-old subjects but less than the average stretch for adults.

SIMPSON K. ROBERT et al. (1981) [38] conducted a study where they examined velar stretch in 20 young, normal adults during the production of /a/, /e/, and /u/, and during blowing. The velar length was measured and results showed no significant differences in the velar stretch between males and females. Using nasal surface measurements, there was a significantly greater stretch for /u/ and for blowing than for /a/ and /s/. Correlations between need ratio and percentage of stretch were significant, as were correlations between percentage of velar stretch (nasal surface measure) and velar height.

This study was conducted in the Department of Oral Medicine and Radiology at Babu Banarasi Das College of Dental Sciences in Lucknow, UP. Authorization to pursue the study was received from the institutional ethical committee having the IEC code 11 and under the Declaration of Helsinki for research involving human subjects (BBDCODS/01/2019). The research was done with patients being seen at the Oral Medicine and Radiology Outpatient Department.

The study sample will consist of 80 patients from both genders between the age range of 8-27, attending the Department of Oral Medicine and Radiology, referred for lateral cephalogram for various purposes, and divided into 4 groups. Group A consist of 10 dyslalics and 10 non dyslalics aged between 8-12 years, Group B consist of 10 dyslalics and 10 non dyslalics aged between 13-17 years, Group C consists of 10 dyslalics and 10 non dyslalics aged between 18-22 years and Group D consists of 10 dyslalics and 10 non dyslalics aged between 23-27 years. Eighty lateral cephalometric radiographs of the subjects were studied and send for statistical analysis.

Armamentarium for examination of patients

1. Dental chair with illuminating facility
2. A pair of sterile disposable gloves and mouth masks
3. Stainless steel kidney tray, mouth mirror, straight probe, tweezers and explorer

Inclusion criteria

1. Subjects who are well oriented to time, place and person.
2. Age groups from 8 to 27 years.

3. Proper visibility of soft palate on the radiograph.

Exclusion Criteria

1. Subjects who are uncooperative, unstable or unable to undergo cephalography procedure and subjects who are not willing to give their consent.
2. Any disorder or abnormality present at birth in the palate that could change the meaning of the image taken.
3. Patients should not have had any diseases of the body that might be affecting the way bones are formed.
4. Patient with facial or palatal deformities or facial trauma.
5. Poor quality radiographs and radiographs with incomplete details.
6. Patient undergoing any kind of orthodontic treatment.

Sampling method

The study group consisted of 80 individuals within the age group of 8-27 years having 40 dyslalic and 40 non dyslalic patients. They were included through random sampling method. The subjects were selected according to the inclusion and exclusion criterion. Detailed case history was recorded in a case history proforma along with subjecting them to Informal assessment method for stigmatism. Following the examination of patient, each patient was informed about the procedures and was given appropriate instructions after a written consent was taken from patients.

Materials and equipments

Used in the study with specifications and company

1. Digital lateral cephalometric radiograph [Planmeca Proline XC, SN:XC430638, 180-240V, 50 Hz]
2. Installed in AERB(Atomic Energy Radiation Board) certified quality assurance facility
3. Planmeca Romexis 2.9.2.R software
4. Modified Informal assessment method of phonation by Felicia Gironda and Renee Fabus to evaluate stigmatism type of dyslalia using:

a. Picture book
b. English & Hindi story book
c. English & Hindi newspaper

MODIFIED INFORMAL ASSESSMENT METHOD OF PHONATION

BY FELICIA GIRONDA AND RENEE FABUS

SH PICTURE BOOK (ENGLISH)







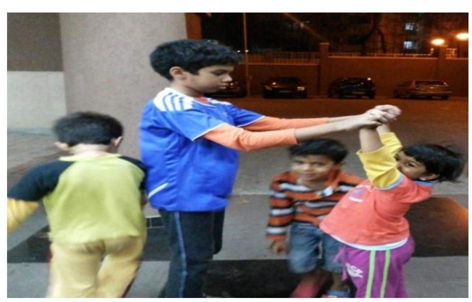


<u>SH PICTURE BOOK (HINDI)</u>










SH SOUND PARAGRAPH (ENGLISH)

Shelly likes going to the beach. She enjoys splashing in the water and walking along the shore collecting sea shells. When she is done filling her bucket with shells, she likes to chill in her beach chair and chew gum. She watches the shoreline for ships and tries to guess where they are going. One time she saw a shark chasing a fish right in the shallow area.

हमारा देश विशेष हैं, यहाँ बहुत सारी भाषा बोली जाती हैं , यह एक कृषि प्रधान देश है , परन्तु इन दिनों उसमे बहुत संघर्ष है।

आने वाले वर्षो में इसे बढ़ने का प्रयास करना होगा। इसके लिए इसकी शिक्षा होना भी आवश्यक हैं। शेष व्यवसाय में शिक्षा के महत्व की पुष्टि स्पष्ट हैं।

SH SOUND NEWSPAPER PARAGRAPH (ENGLISH)

Anger in diplomacy: On Indian reaction to MNC Kashmir tweets.

Pak. establishment was behind MNC Kashmir tweets, but India should have shown restraint

The advent of social media has no doubt changed how diplomacy is conducted between countries.

However, where a sharp word or even a short statement of disapproval would have sufficed, the Modi government decided to go the whole distance: even summoning the Korean Ambassador while ensuring that Indian embassies took up the issue with other governments.

SH SOUND NEWSPAPER PARAGRAPH (HINDI)

राजधानी में कोरोना संक्रमण के कम होते मामलों के बीच आज सेनर्सरी से लेकर आठवीं तक की ऑफलाइन कक्षाएं शुरू हो रही हैं।

स्कूल खोलने को लेकर बीते दिनों दिल्ली सरकार के शिक्षा निदेशालय ने स्कूलों व बच्चों के लिए दिशा निर्देश जारी कर दिए गए थे। स्कूलों को निर्देश है कि शिक्षकों को पहले दिन बच्चों व अभिभावकों के साथ गर्मजोशी से पेशा आना होगा। कक्षा शुरू होने पर शुरु आती एक सप्ताह में अधिक दबाव नहीं बनाया जाएगा।लंबे समय बाद स्कूल पहुंचने पर कोई भी बच्चा अकेला महसूस न करे, इसके लिए शिक्षकों को बच्चों का जोड़ा या समूह का गठन करना होगा। बिना सहमति पत्र के नहीं मिलेगा प्रवेश. शिक्षा निदेशालय ने स्पष्ट किया है कि स्कूल पहुंचने के लिए छात्रों को अपने साथ अभिभावकों से मिला सहमति पत्र ले जाना होगा। यदि बच्चा बिना सहमति पत्र के स्कूल पहुंचता है तो उसे स्कूल प्रशासन की ओर से प्रवेश नहीं दिया जाएगा

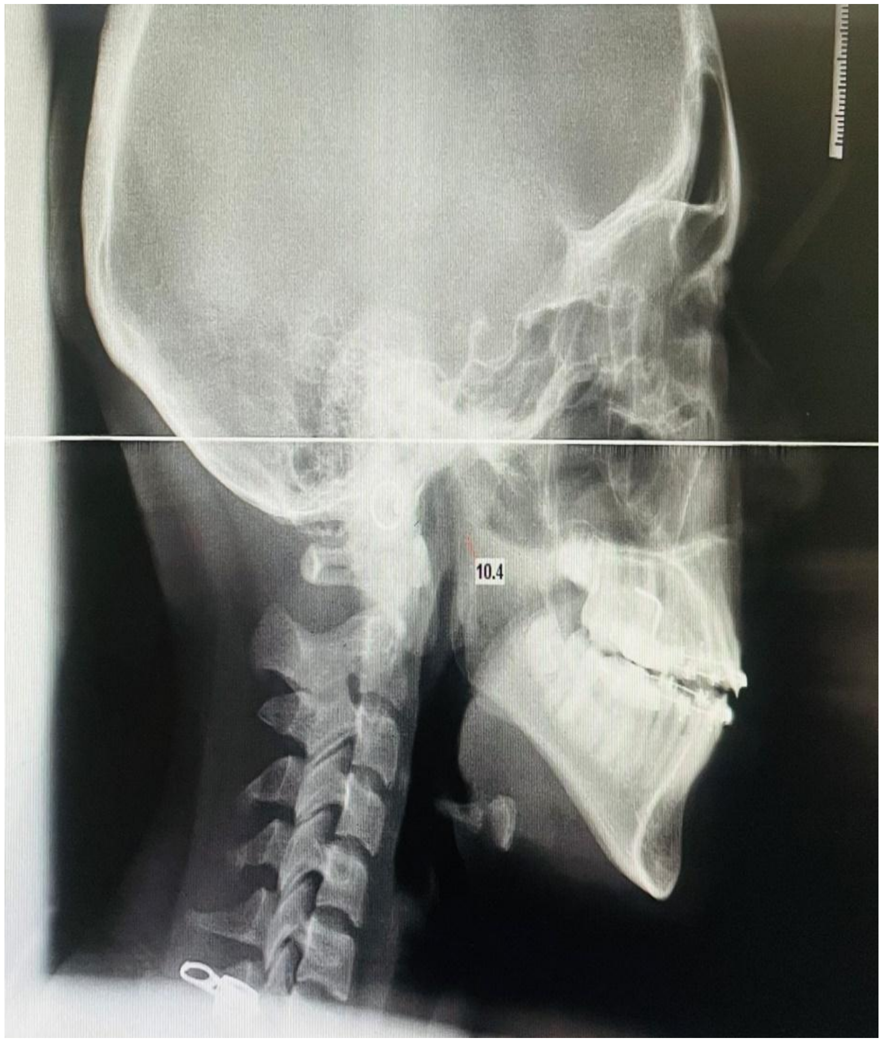
Methodology

In the present study, all the subjects fulfilling the above criteria will be enrolled after obtaining informed consent. All the enrolled subjects will be grouped into 4, each group having 20 patients each: GROUP A: 8-12 yrs, GROUP B: 13-17 yrs, GROUP C: 18-22yrs and GROUP D: 23-27yrs. The individuals selected to participate in the study will need to meet the requirements as described above. They will be situated in the cephalostat where their upper and lower teeth will be placed in centric occlusions with a relaxed oropharyngeal musculature before the digital lateral cephalogram is taken. From there, the antero-posterior and supero-inferior dimensions as well as the morphology of the velum will be examined. Furthermore, the length of the velum will be determined by measuring the distance between the posterior nasal spine and the uvula of the soft palate, and the thickness will be established at the thickest point. Patient will be examined for Dyslalia using Informal Assessment.

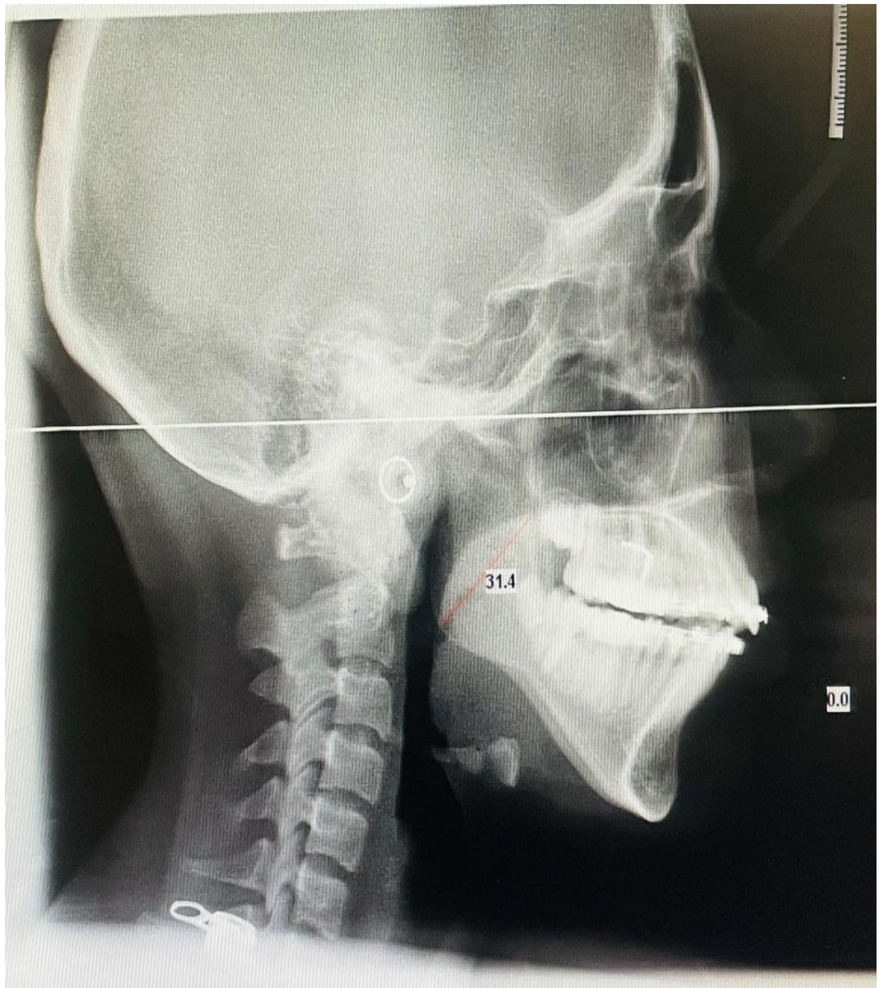
Method for sigmatism type of dyslalia which is a modification of informal Assessment Method of phonation given by Felicia Gironda And Renee Fabus. All the relevant data will be entered in the proforma and will then be sorted, tabulated and statistically analyzed to draw conclusion.

PHOTOGRAPH 1: Armamentarium – Diagnostics (kidney tray, mouth mirror, probe, explorer, tweezer), gloves, mouth mask, head cap

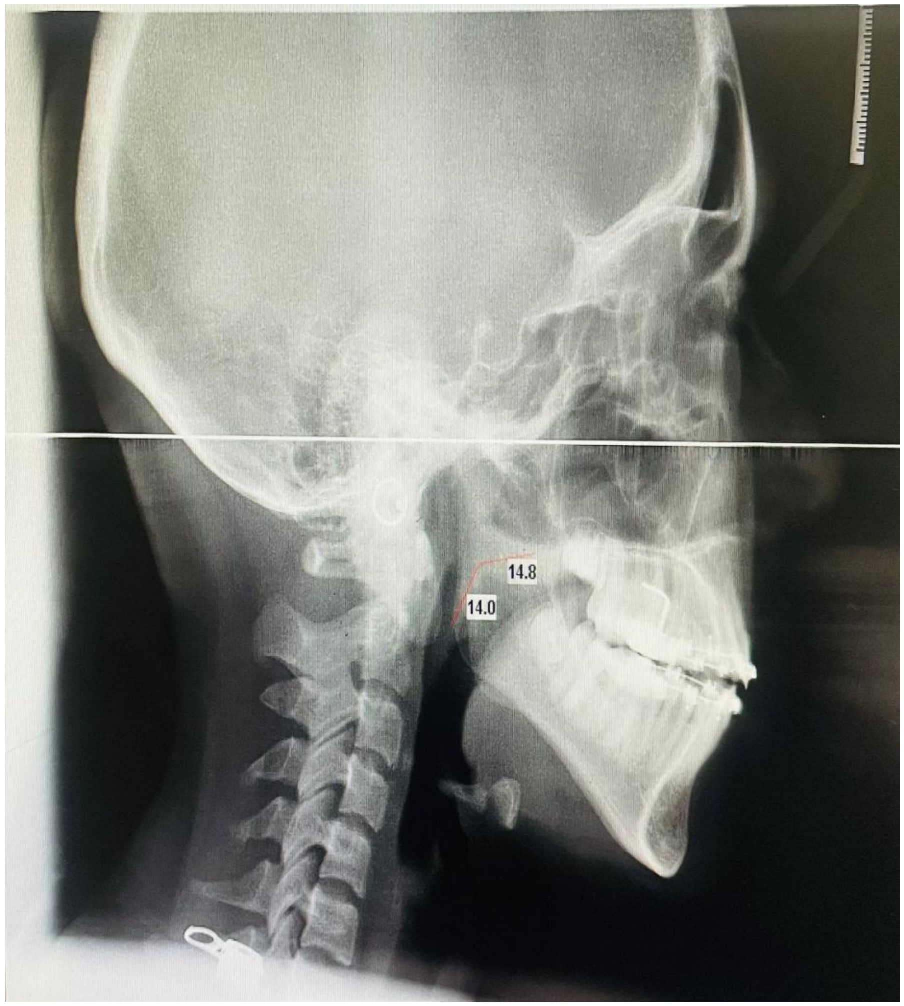
PHOTOGRAPH 2: Patient along with the Lateral Cephalometric Machine



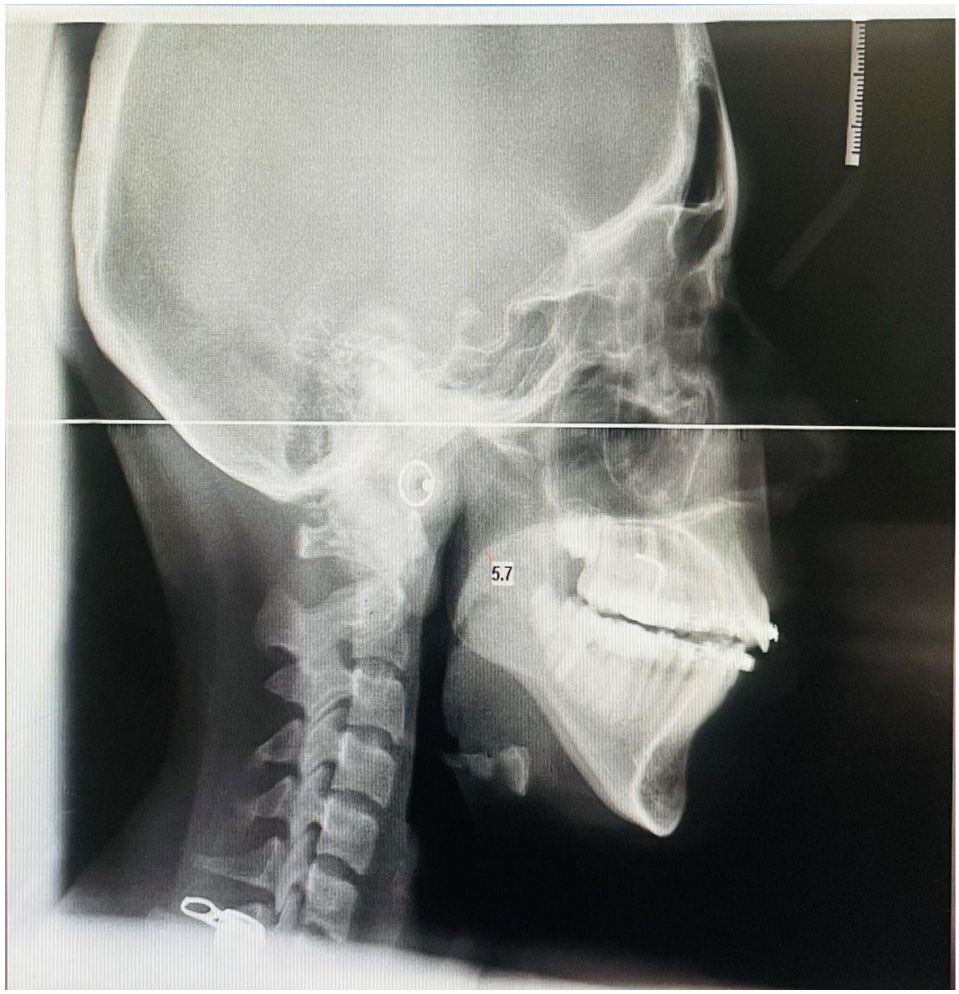
PHOTOGRAPH 3: Romex software used for taking Lateral Cephalometric Radiograph



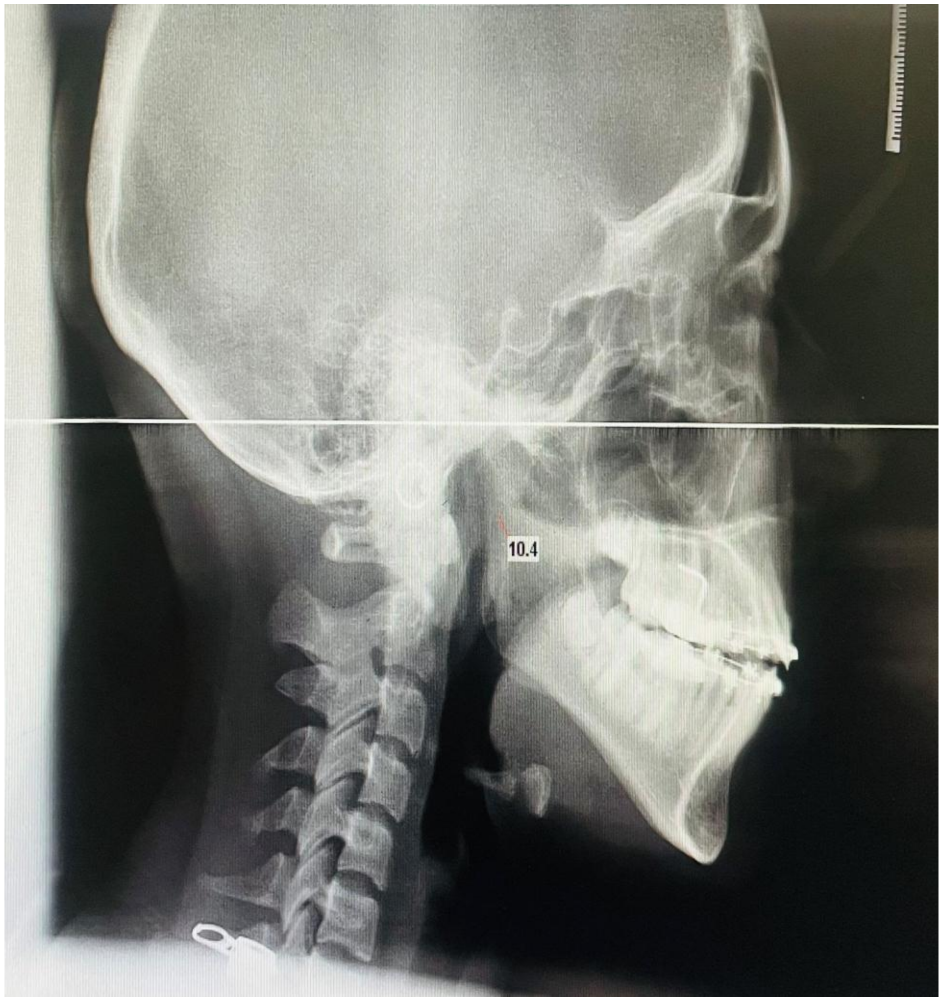
PHOTOGRAPH 4: Showing velar length at rest



PHOTOGRAPH 5: Showing velar length while phonation



PHOTOGRAPH 6: Showing velar thickness at rest



PHOTOGRAPH 7: Showing velar thickness while phonation

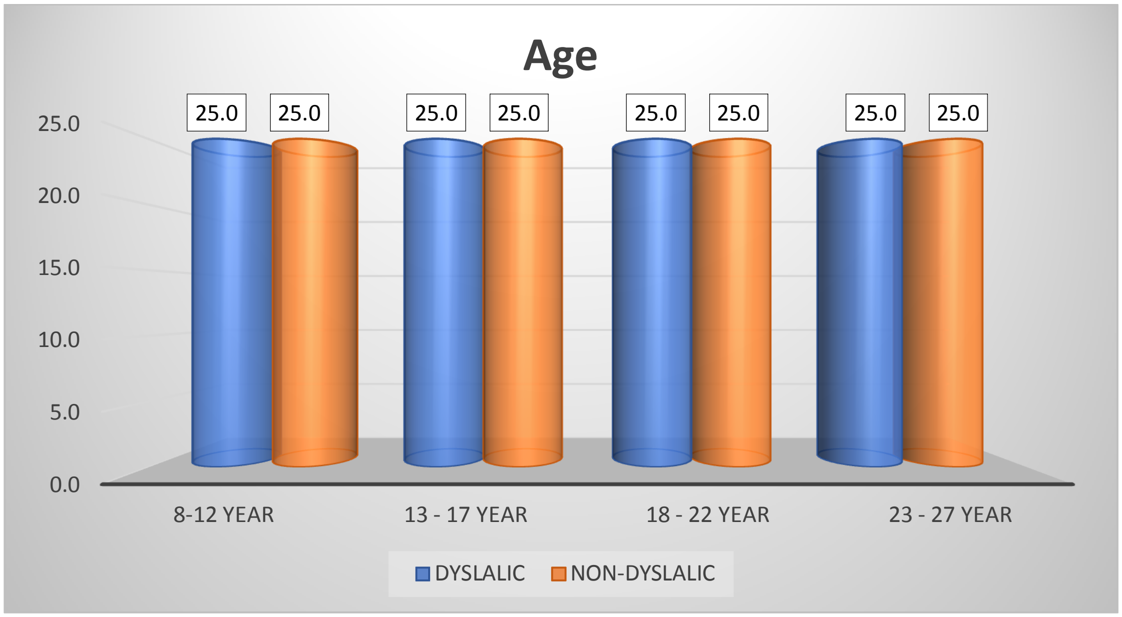
The present study was conducted at the Department of Oral Medicine and Radiology of Babu Banarasi Das College of Dental Sciences, Lucknow (U.P.). After obtaining ethical clearance and informed consent, 80 patients of age group 8-27 years divided into four age groups at an interval of 5 years were enrolled in the study in accordance with the aforementioned inclusion and exclusion criteria, after which they were subjected to two lateral cephalographs. All the enrolled patients were equally divided into two subgroups viz. Dyslalics and non Dyslalics.

PART 1: AGE AND GENDER DISTRIBUTION

Table: 1 Association between age and Subgroups among study population

Age	DYSLALIC		NON-DYSLALIC		Chi-square Statistics (P value)
	Frequency	**Percent**	**Frequency**	**Percent**	
8-12 year	10	25.0%	10	25.0%	0.000 (1.00)
13 - 17 year	10	25.0%	10	25.0%	
18 - 22 year	10	25.0%	10	25.0%	
23 - 27 year	10	25.0%	10	25.0%	
Total	40	100.0%	40	100.0%	
Mean±SD = 17.8±6.03					

Graphs 1: Distribution of percentage of age of study population

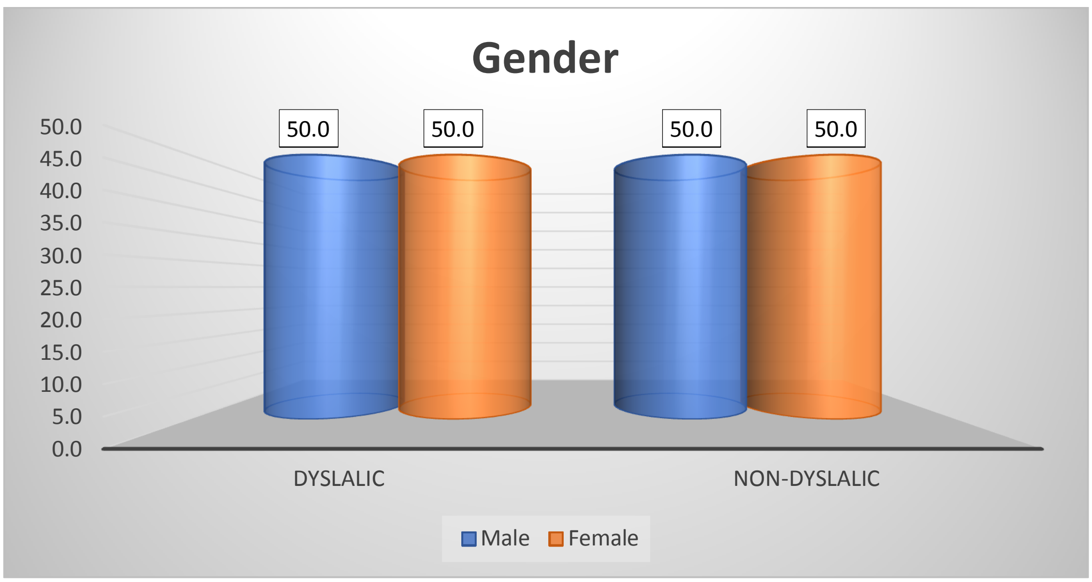


Among 80 patient, studied that 25% of patient comes under in all age group equally in both subgroup, and there is an insignificant association (**p value =1.00> 0.05)** between age group and subgroup (DYSLALIC & NON DYSLALIC).

Table: 2 Association between Gender and Subgroups among study population

Gender	DYSLALIC		NON-DYSLALIC		Chi-square Statistics (P value)
	Frequency	Percent	Frequency	Percent	
Male	20	50.0%	20	50.0%	0.000 (1.00)
Female	20	50.0%	20	50.0%	
Total	40	100.0%	40	100.0%	

Graph 2: Distribution of percentage of gender of study population



Among 80 patient, studied that 50% of patient was male & female in both subgroup, and there is an insignificant association between gender and subgroup (DYSLALIC & NON DYSLALIC) i.e. **p value (=1.00) > 0.05.**

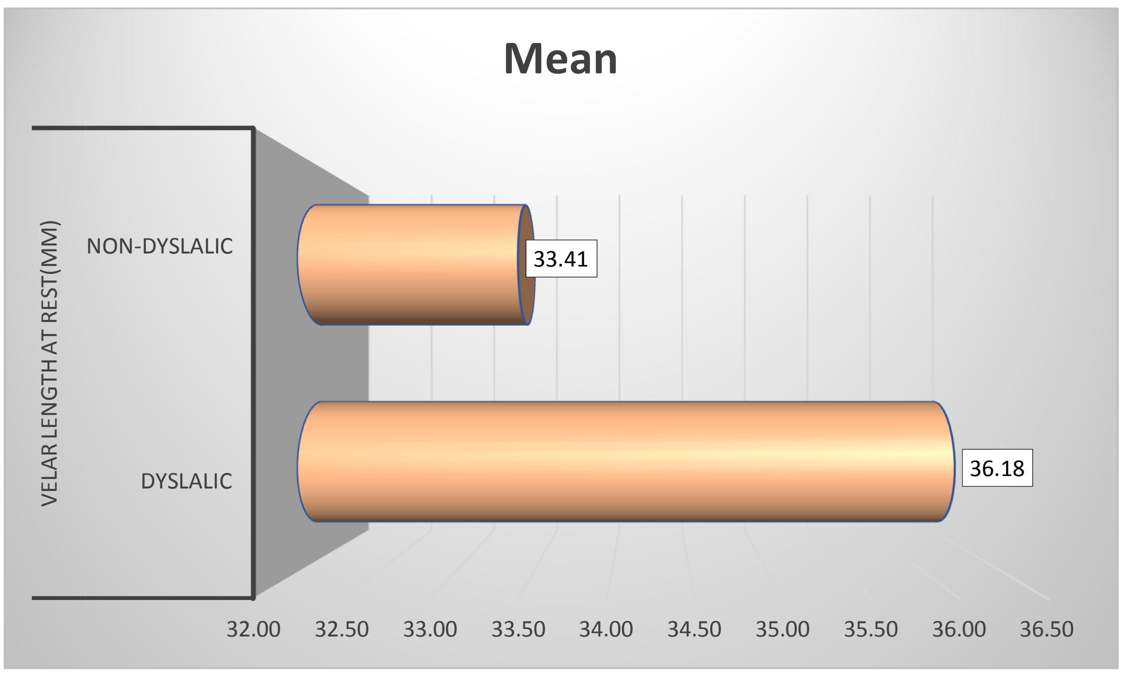
PART 2: VELAR LENGTH

A. VELAR LENGTH AT REST

Table: 3 Comparison between mean of Velar Length at rest (mm) among subgroups of study population

Velar Length at rest(mm)	DYSLALIC		NON-DYSLALIC		P - value
	Mean	Standard Dev.	Mean	Standard Dev.	
	36.18	5.43	33.41	4.69	**0.017**

Graph 3: Figure showing the mean of Velar Length at rest (mm) among subgroups of study population



Among 80 patients, studied that there is a statistically significant difference **(p value < 0.05)** between DYSLALIC & NON DYSLALIC of velar length at rest (mm) with mean values of 36.18 +/- 5.43 as compared to 33.41 +/- 4.69 in non dyslalics.

Table: 4 (a) Effect of advancement of age on velar length at rest (mm) and (b) Comparison of the study population's age group and Velar Length at Rest (mm) in the DYSLALIC group

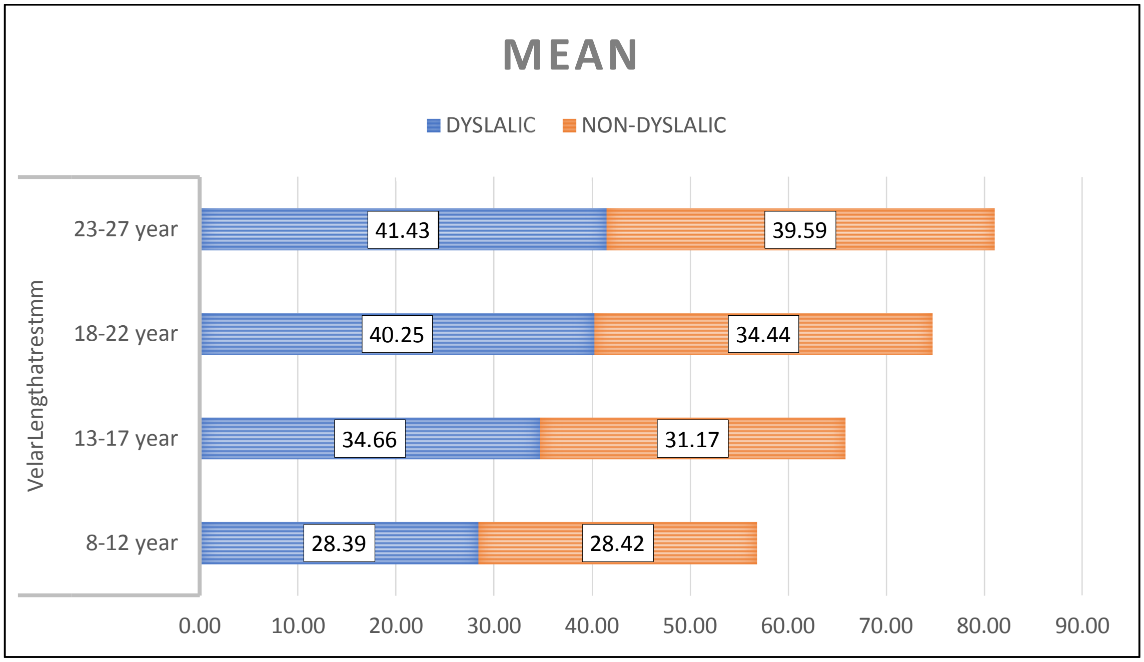
Velar Length at rest(mm)	8-12 year		13-17 year		18-22 year		23-27 year		P - value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	28.39	0.78	34.66	2.20	40.25	1.22	41.43	1.38	**0.000**

Tukey's multiple comparisons test		Mean Difference (I-J)	Sig.	95% Confidence Interval	
(I)	(J)			Lower Bound	Upper Bound
8-12 year	13-17 year	-6.2700*	**.000**	-8.06	-4.48
	18-22 year	-11.8600*	**.000**	-13.65	-10.07
	23-27 year	-13.0400*	**.000**	-14.83	-11.25
13-17 year	8-12 year	6.2700*	**.000**	4.48	8.06
	18-22 year	-5.5900*	**.000**	-7.38	-3.80
	23-27 year	-6.7700*	**.000**	-8.56	-4.98
18-22 year	8-12 year	11.8600*	**.000**	10.07	13.65
	13-17 year	5.5900*	**.000**	3.80	7.38
	23-27 year	-1.1800	.303	-2.97	.61
23-27 year	8-12 year	13.0400*	**.000**	11.25	14.83
	13-17 year	6.7700*	**.000**	4.98	8.56
	18-22 year	1.1800	.303	-.61	2.97

Table: 5(a) Effect of advancement of age on velar length at rest (mm) and (b) Comparison of the study population's age group and Velar Length at Rest (mm) in the NON-DYSLALIC group

Velar Length at rest(mm)	8-12 year		13-17 year		18-22 year		23-27 year		P - value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	28.42	1.21	31.17	1.30	34.44	2.96	39.59	2.58	**0.000**

Tukey's multiple comparisons test		Mean Difference (I-J)	Sig.	95% Confidence Interval	
(I)	**(J)**			**Lower Bound**	**Upper Bound**
8-12 year	13-17 year	-2.7500^{*}	**.035**	-5.35	-0.15
	18-22 year	-6.0200^{*}	**.000**	-8.62	-3.42
	23-27 year	-11.1700^{*}	**.000**	-13.77	-8.57
13-17 year	8-12 year	2.7500^{*}	**.035**	0.15	5.35
	18-22 year	-3.2700^{*}	**.009**	-5.87	-0.67
	23-27 year	-8.4200^{*}	**.000**	-11.02	-5.82
18-22 year	8-12 year	6.0200^{*}	**.000**	3.42	8.62
	13-17 year	3.2700^{*}	**.009**	0.67	5.87
	23-27 year	-5.1500^{*}	**.000**	-7.75	-2.55
23-27 year	8-12 year	11.1700^{*}	**.000**	8.57	13.77
	13-17 year	8.4200^{*}	**.000**	5.82	11.02
	18-22 year	5.1500^{*}	**.000**	2.55	7.75



Graph 4: Showing the mean of Velar Length at rest (mm) among subgroups of study population at different age groups

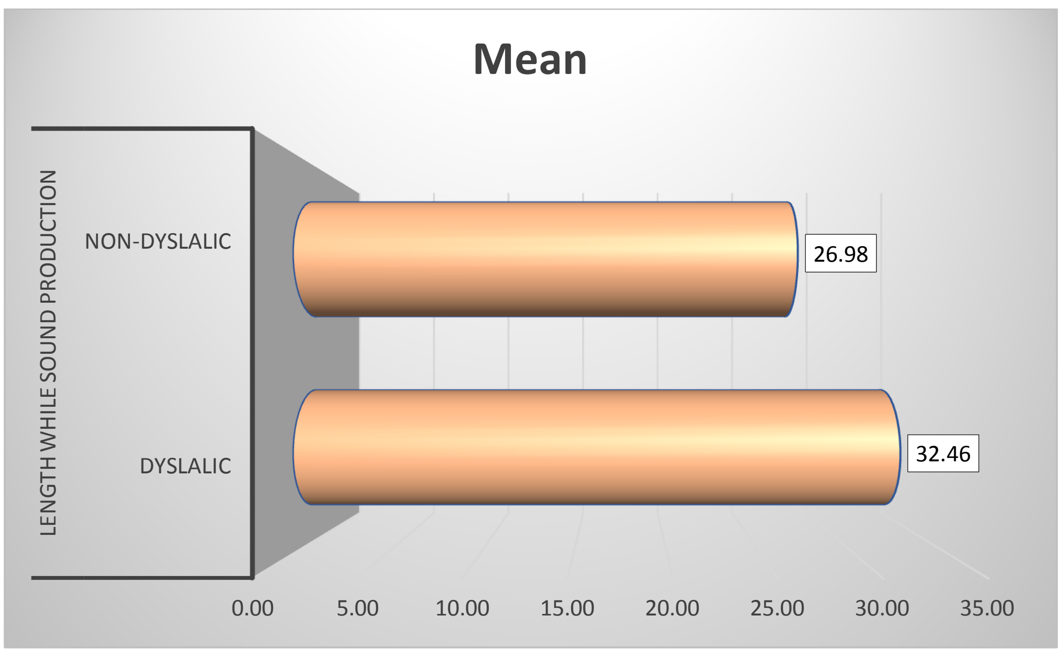
Among 20 patients in each age groups further subdivided into 10 patients in each subgroups viz. dyslalics and non dyslalics, studied that there is a statistically significant difference **(p value < 0.05)** in DYSLALIC & NON DYSLALIC of velar length at rest (mm) at each age groups. In dyslalics, velar length at rest were 28 +/- 0.78 mm, 34.66 +/- 2.20 mm, 40.25 +/- 1.22 mm and 41.43 +/- 1.38mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. In non dyslalics, velar length at rest were 28.42 +/- 1.21 mm, 31.17 +/- 1.30 mm, 34.44 +/- 2.96 mm and 39.59 +/- 2.58mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively.

B. VELAR LENGTH WHILE PHONATION

Table: 6 Comparison between mean of Velar Length while phonation (mm) among subgroups of study population

Velar Length while phonation	DYSLALIC		NON-DYSLALIC		P - value
	Mean	Standard Dev.	Mean	Standard Dev.	
	32.46	4.34	26.98	4.23	**0.000**

Graph 5: Showing the mean of Velar Length while phonation (mm) among subgroups of study population



Among 80 patients, studied that there is a statistically significant difference **(p value < 0.05)** between DYSLALIC & NON DYSLALIC of length while phonation.

Table: 7 (a) Effect of advancement of age on velar length at while phonation (mm) and (b) Comparison of the study population's age group and Velar Length while phonation (mm) in the DYSLALIC group

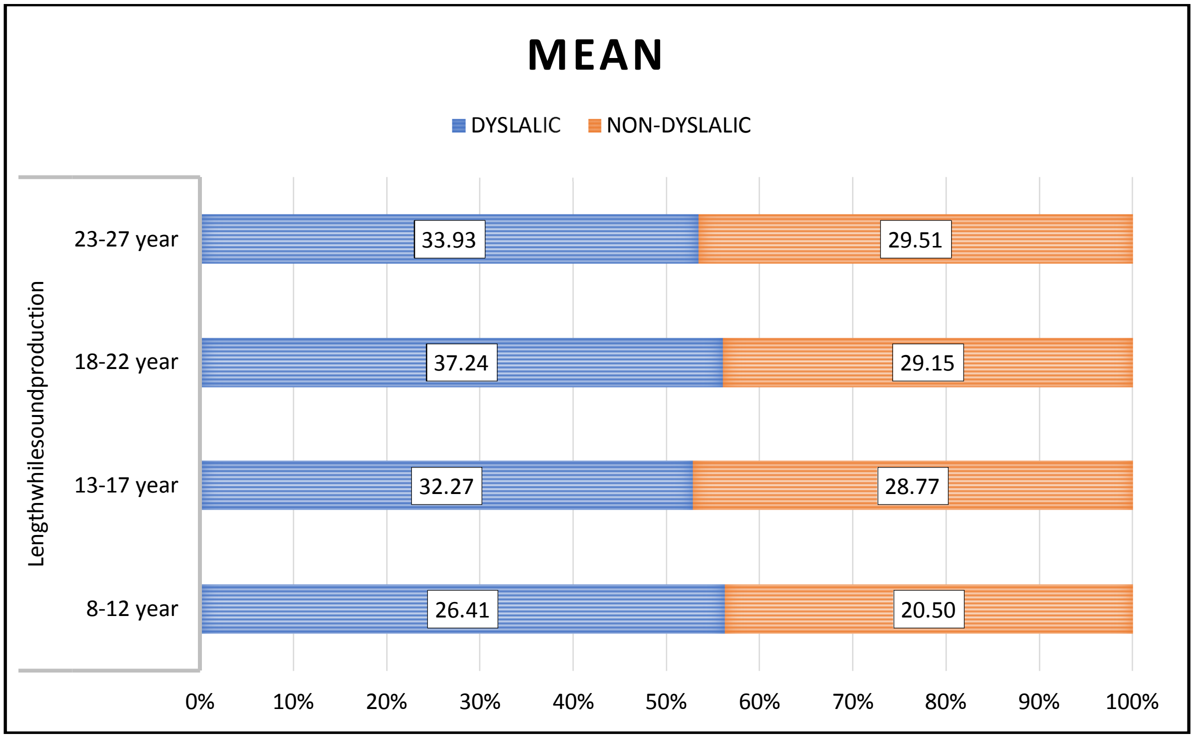
Length while phonation	8-12 year		13-17 year		18-22 year		23-27 year		P - value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	26.41	1.34	32.27	2.31	37.24	2.18	33.93	1.13	**0.000**

Tukey's multiple comparisons test		Mean Difference (I-J)	Sig.	95% Confidence Interval	
(I)	**(J)**			**Lower Bound**	**Upper Bound**
8-12 year	13-17 year	-5.8600*	**.000**	-8.05	-3.67
	18-22 year	-10.8300*	**.000**	-13.02	-8.64
	23-27 year	-7.5200*	**.000**	-9.71	-5.33
13-17 year	8-12 year	5.8600*	**.000**	3.67	8.05
	18-22 year	-4.9700*	**.000**	-7.16	-2.78
	23-27 year	-1.6600	.191	-3.85	.53
18-22 year	8-12 year	10.8300*	**.000**	8.64	13.02
	13-17 year	4.9700*	**.000**	2.78	7.16
	23-27 year	3.3100*	**.001**	1.12	5.50
23-27 year	8-12 year	7.5200*	**.000**	5.33	9.71
	13-17 year	1.6600	.191	-.53	3.85
	18-22 year	-3.3100*	**.001**	-5.50	-1.12

Table: 8 (a) Effect of advancement of age on velar length while phonation (mm) and (b) Comparison of the study population's age group and Velar Length while phonation (mm) in the NON-DYSLALIC group

Length while phonation	**8-12 year**		**13-17 year**		**18-22 year**		**23-27 year**		**P - value**
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	20.50	2.13	28.77	1.17	29.15	2.54	29.51	1.64	**0.000**

Tukey's multiple comparisons test		**Mean Difference (I-J)**	**Sig.**	**95% Confidence Interval**	
(I)	**(J)**			**Lower Bound**	**Upper Bound**
8-12 year	13-17 year	-8.2700*	.000	-10.61	-5.93
	18-22 year	-8.6500*	.000	-10.99	-6.31
	23-27 year	-9.0100*	.000	-11.35	-6.67
13-17 year	8-12 year	8.2700*	.000	5.93	10.61
	18-22 year	-.3800	.971	-2.72	1.96
	23-27 year	-.7400	.828	-3.08	1.60
18-22 year	8-12 year	8.6500*	.000	6.31	10.99
	13-17 year	.3800	.971	-1.96	2.72
	23-27 year	-.3600	.976	-2.70	1.98
23-27 year	8-12 year	9.0100*	.000	6.67	11.35
	13-17 year	.7400	.828	-1.60	3.08
	18-22 year	.3600	.976	-1.98	2.70



Graph 6: Showing the mean of Velar Length while phonation (mm) among subgroups of study population at different age groups

Among 20 patients in each age groups further subdivided into 10 patients in each subgroups viz. dyslalics and non dyslalics, studied that there is a statistically significant difference **(p value < 0.05)** in DYSLALIC & NON DYSLALIC of velar length while phonation (mm) at each age groups. In dyslalics, velar length while phonation were 26.41 +/- 1.34 mm, 32.27 +/- 2.31 mm, 37.24 +/- 2.18 mm and 33.93 +/- 1.13 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively.) In non dyslalics, velar length while phonation were 20.50 +/- 2.13 mm, 28.77 +/- 1.17 mm, 29.15 +/- 2.54 mm and 29.51 +/- 1.64 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively.

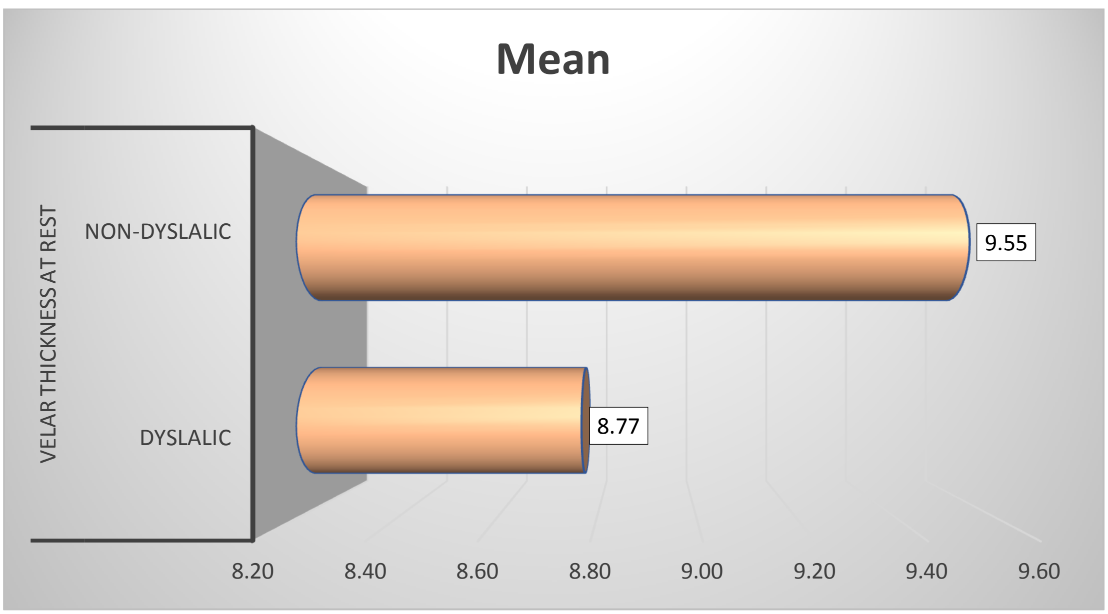
PART 3: VELAR THICKNESS

A. VELAR THICKNESS AT REST

Table: 9 Comparison between mean of Velar thickness at rest (mm) among subgroups of study population

Velar thickness at rest	DYSLALIC		NON-DYSLALIC		P - value
	Mean	Standard Dev.	Mean	Standard Dev.	
	8.77	1.41	9.55	1.86	**0.039**

Graph 7 Showing the mean of Velar thickness at rest (mm) among subgroups of study population



Among 80 patients, studied that there is a statistically significant difference **(p value < 0.05)** between DYSLALIC & NON DYSLALIC of velar thickness at rest.

Table: 10 (a) Effect of advancement of age on velar thickness at rest (mm) and (b) Comparison of the study population's age group and Velar Length at rest (mm) in the DYSLALIC group

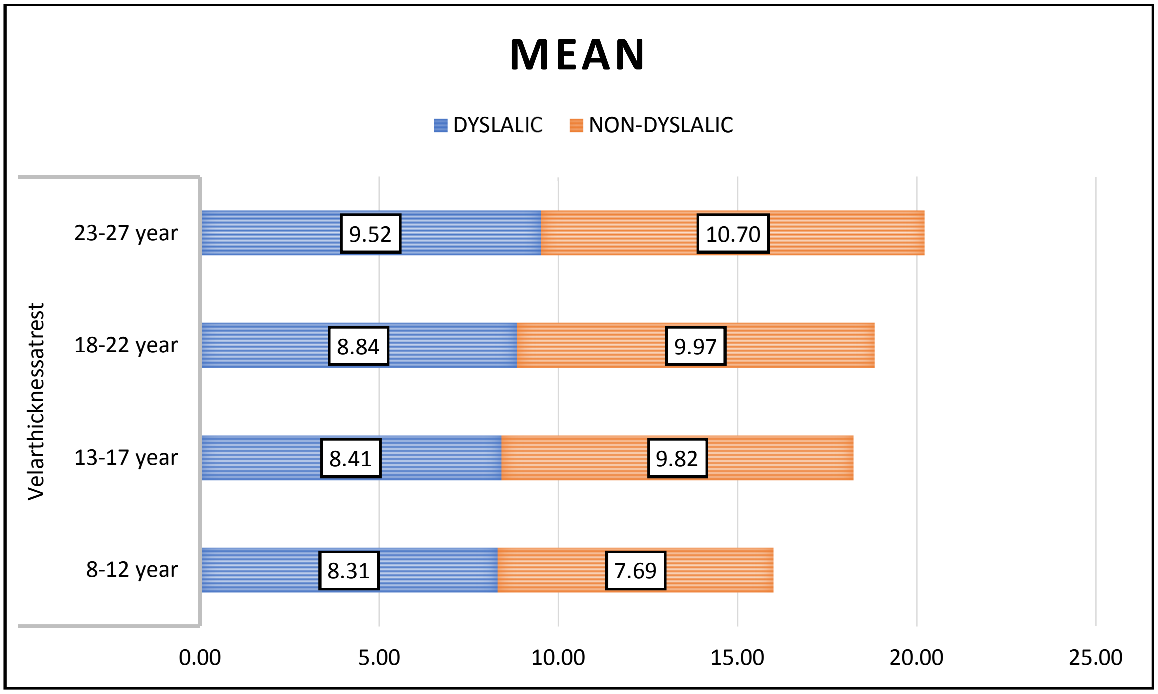
Velar thickness at rest	8-12 year		13-17 year		18-22 year		23-27 year		P - value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	8.31	0.95	8.41	1.14	8.84	2.25	9.52	0.63	**0.211**

Tukey's multiple comparisons test		Mean Difference (I-J)	Sig.	95% Confidence Interval	
(I)	**(J)**			**Lower Bound**	**Upper Bound**
8-12 year	13-17 year	-.1000	.998	-1.77	1.57
	18-22 year	-.5300	.827	-2.20	1.14
	23-27 year	-1.2100	.224	-2.88	.46
13-17 year	8-12 year	.1000	.998	-1.57	1.77
	18-22 year	-.4300	.898	-2.10	1.24
	23-27 year	-1.1100	.293	-2.78	.56
18-22 year	8-12 year	.5300	.827	-1.14	2.20
	13-17 year	.4300	.898	-1.24	2.10
	23-27 year	-.6800	.692	-2.35	.99
23-27 year	8-12 year	1.2100	.224	-.46	2.88
	13-17 year	1.1100	.293	-.56	2.78
	18-22 year	.6800	.692	-.99	2.35

Table: 11 (a) Effect of advancement of age on velar thickness at rest (mm) and (b) Comparison of the study population's age group and Velar Thickness at Rest (mm) in the NON-DYSLALIC group

Velar thickness at rest	8-12 year		13-17 year		18-22 year		23-27 year		P - value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	7.69	1.29	9.82	1.26	9.97	2.30	10.70	0.89	**0.001**

Tukey's multiple comparisons test		Mean Difference (I-J)	Sig.	95% Confidence Interval	
(I)	(J)			Lower Bound	Upper Bound
8-12 year	13-17 year	-2.1300*	**.018**	-3.97	-0.29
	18-22 year	-2.2800*	**.010**	-4.12	-0.44
	23-27 year	-3.0100*	**.001**	-4.85	-1.17
13-17 year	8-12 year	2.1300*	**.018**	0.29	3.97
	18-22 year	-.1500	.996	-1.99	1.69
	23-27 year	-.8800	.576	-2.72	0.96
18-22 year	8-12 year	2.2800*	**.010**	0.44	4.12
	13-17 year	.1500	.996	-1.69	1.99
	23-27 year	-.7300	.710	-2.57	1.11
23-27 year	8-12 year	3.0100*	**.001**	1.17	4.85
	13-17 year	.8800	.576	-0.96	2.72
	18-22 year	.7300	.710	-1.11	2.57



Graph 8 Showing the mean of Velar thickness at rest (mm) among subgroups of study population at different age groups

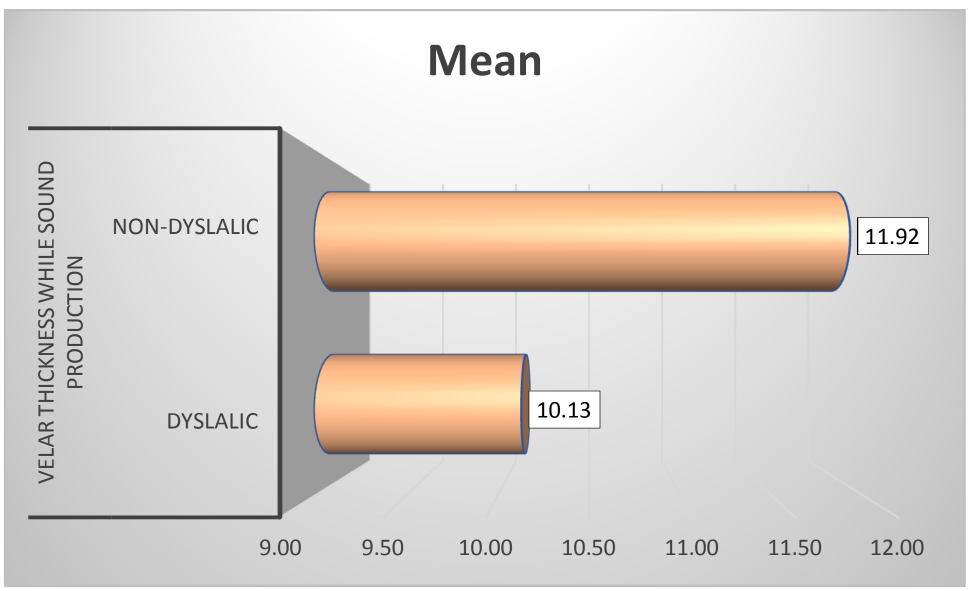
Among 20 patients in each age groups further subdivided into 10 patients in each subgroups viz. dyslalics and non dyslalics, studied that there is a statistically significant difference **(p value < 0.05)** in DYSLALIC & NON DYSLALIC of velar thickness while rest (mm) at each age groups. In dyslalics, velar thickness at rest were 8.31 +/- 0.95 mm, 8.41 +/- 1.14 mm, 8.84 +/- 2.25 mm and 9.52 +/- 0.63 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively.) In non dyslalics, velar thickness at rest were 7.69 +/- 1.29 mm, 9.82 +/- 1.26 mm, 9.97 +/- 2.30 mm and 10.70+/- 0.89 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively.

B. VELAR THICKNESS WHILE PHONATION

Table: 12 Comparison between mean of Velar Thickness while phonation (mm) among subgroups of study population

Velar thickness while phonation	DYSLALIC		NON-DYSLALIC		P - value
	Mean	Standard Dev.	Mean	Standard Dev.	
	10.13	1.25	11.92	2.00	**0.000**

Graph 9 Showing the mean of Velar Thickness while phonation (mm) among subgroups of study population



Among 80 patients, studied that there is a statistically significant difference **(p value < 0.05)** between DYSLALIC & NON DYSLALIC of Velar thickness while phonation

Table: 13 (a) Effect of advancement of age on velar thickness at while phonation (mm) and (b) Comparison of the study population's age group and velar thickness while phonation (mm) in the DYSLALIC group

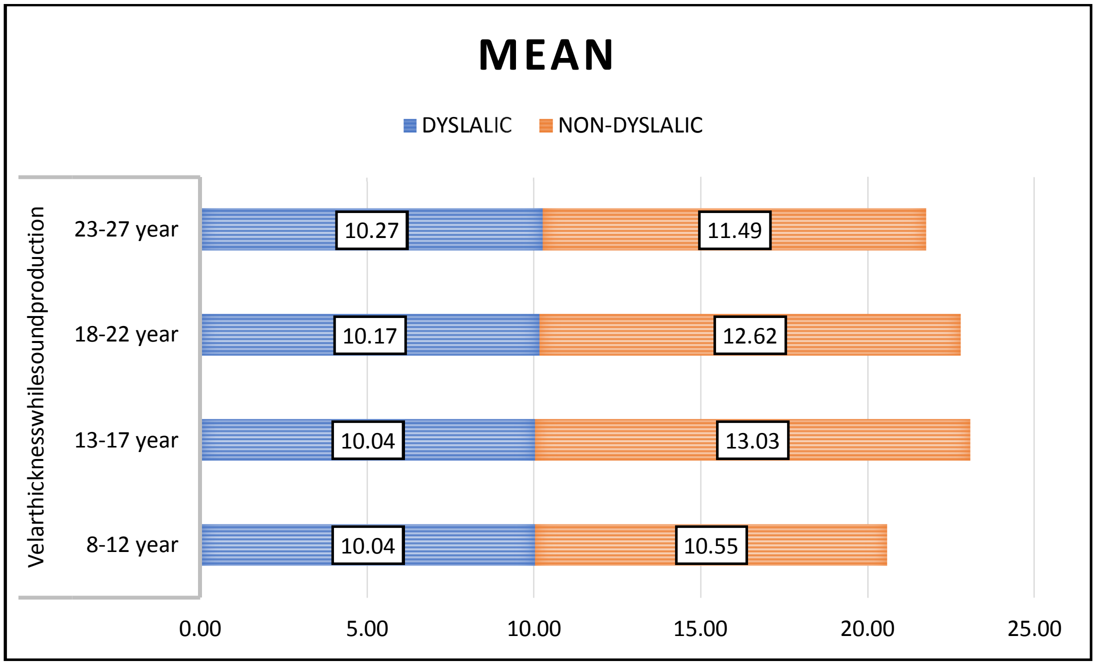
Velar thickness while phonation	8-12 year		13-17 year		18-22 year		23-27 year		P - value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	10.04	1.14	10.04	1.02	10.17	1.89	10.27	0.90	0.974

Tukey's multiple comparisons test		Mean Difference (I-J)	Sig.	95% Confidence Interval	
(I)	(J)			Lower Bound	Upper Bound
8-12 year	13-17 year	0.0000	1.000	-1.56	1.56
	18-22 year	-.1300	.996	-1.69	1.43
	23-27 year	-.2300	.979	-1.79	1.33
13-17 year	8-12 year	0.0000	1.000	-1.56	1.56
	18-22 year	-.1300	.996	-1.69	1.43
	23-27 year	-.2300	.979	-1.79	1.33
18-22 year	8-12 year	.1300	.996	-1.43	1.69
	13-17 year	.1300	.996	-1.43	1.69
	23-27 year	-.1000	.998	-1.66	1.46
23-27 year	8-12 year	.2300	.979	-1.33	1.79
	13-17 year	.2300	.979	-1.33	1.79
	18-22 year	.1000	.998	-1.46	1.66

Table: 14 (a) Effect of advancement of age on velar thickness while phonation (mm) and (b) Comparison of the study population's age group and Velar thickness while phonation (mm) in the NON-DYSLALIC group

Velar thickness while phonation	**8-12 year**		**13-17 year**		**18-22 year**		**23-27 year**		**P - value**
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	10.55	1.07	13.03	1.07	12.62	3.17	11.49	0.90	**0.018**

Tukey's multiple comparisons test		**Mean Difference (I-J)**	**Sig.**	**95% Confidence Interval**	
(I)	**(J)**			**Lower Bound**	**Upper Bound**
8-12 year	13-17 year	-2.4800*	**.021**	-4.67	-0.29
	18-22 year	-2.0700	.069	-4.26	0.12
	23-27 year	-.9400	.657	-3.13	1.25
13-17 year	8-12 year	2.4800*	**.021**	0.29	4.67
	18-22 year	.4100	.957	-1.78	2.60
	23-27 year	1.5400	.248	-0.65	3.73
18-22 year	8-12 year	2.0700	**.069**	-0.12	4.26
	13-17 year	-.4100	.957	-2.60	1.78
	23-27 year	1.1300	.513	-1.06	3.32
23-27 year	8-12 year	.9400	.657	-1.25	3.13
	13-17 year	-1.5400	.248	-3.73	0.65
	18-22 year	-1.1300	.513	-3.32	1.06



Graph 10: Showing the mean of Velar thickness while phonation (mm) among subgroups of study population at different age groups

Among 20 patients in each age groups further subdivided into 10 patients in each subgroups viz. dyslalics and non dyslalics, studied that there is a statistically significant difference **(p value < 0.05)** in DYSLALIC & NON DYSLALIC of velar thickness while phonation (mm) at each age groups. In dyslalics, velar thickness while phonation were 10.04 +/- 1.14 mm, 10.04 +/- 1.02 mm, 10.17 +/- 1.89 mm and 10.27 +/- 0.90 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. In non dyslalics, velar thickness while phonation were 10.55 +/- 1.07 mm, 13.03 +/- 1.07 mm, 12.62 +/- 3.17 mm and 11.49+/- 0.90 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively.

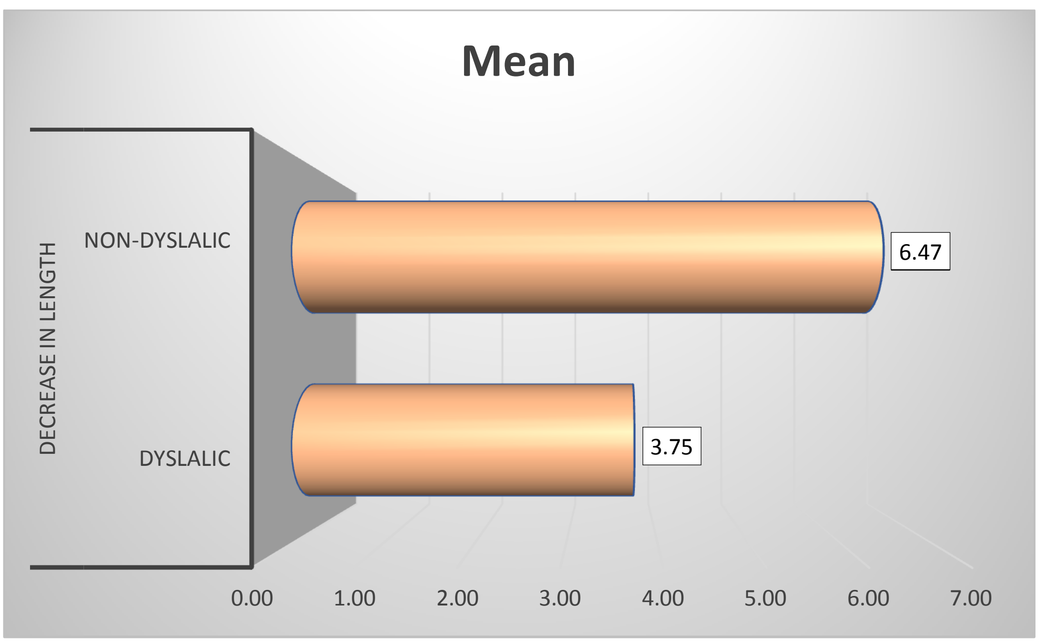
PART 4: VELAR RETRACTION

A. DECREASE IN VELAR LENGTH [VELAR LENGTH AT REST – VELAR LENGTH WHILE PHONATION]

Table: 15 Comparison between mean of decrease in velar length among Subgroups of study population

Decrease in Velar length	DYSLALIC		NON-DYSLALIC		P - value
	Mean	Standard Dev.	Mean	Standard Dev.	
	3.75	2.67	6.47	3.74	**0.000**

Graph 11 Showing the mean of decrease in velar length among Subgroups of study population



Among 80 patients, studied that there is a statistically significant difference **(p value < 0.05)** between DYSLALIC & NON DYSLALIC of decrease in velar length.

Table: 16 (a) Effect of advancement of age on mean of decrease in velar length (mm) and (b) Comparison of the study population's age group and decrease in velar length (mm) in the DYSLALIC group

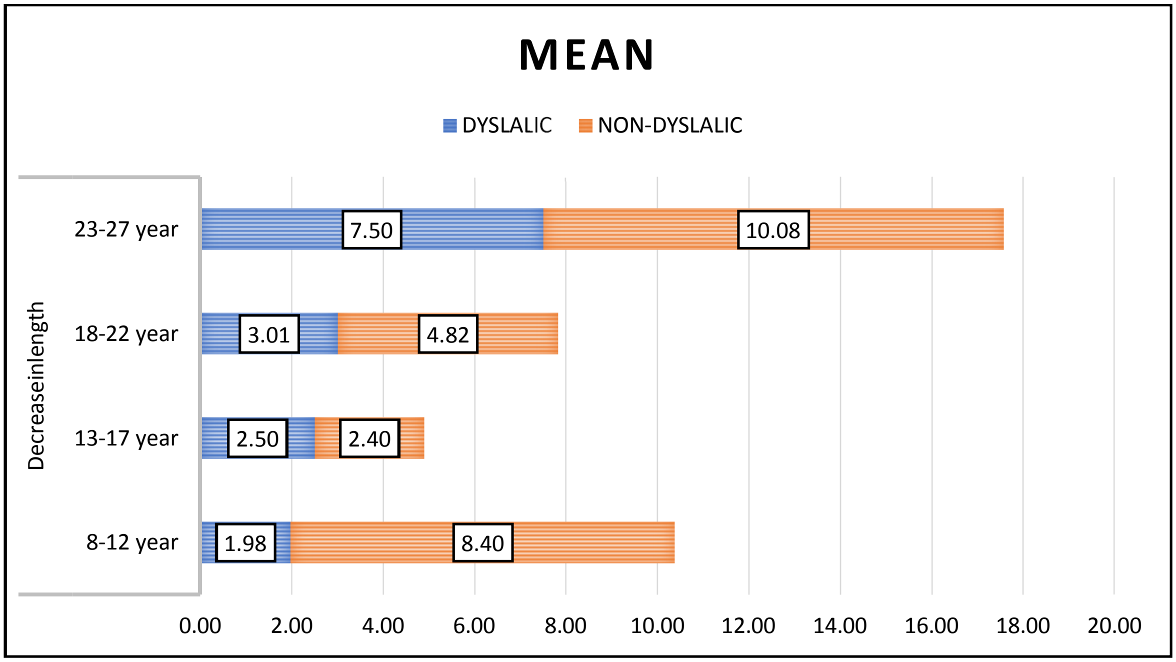
Decrease in Velar length	**8-12 year**		**13-17 year**		**18-22 year**		**23-27 year**		**P - value**
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	1.98	1.31	2.50	1.40	3.01	1.79	7.50	1.56	**0.000**

Tukey's multiple comparisons test		**Mean Difference (I-J)**	**Sig.**	**95% Confidence Interval**	
(I)	**(J)**			**Lower Bound**	**Upper Bound**
8-12 year	13-17 year	-.5200	.871	-2.36	1.32
	18-22 year	-1.0300	.444	-2.87	.81
	23-27 year	-5.5200*	**.000**	-7.36	-3.68
13-17 year	8-12 year	.5200	.871	-1.32	2.36
	18-22 year	-.5100	.878	-2.35	1.33
	23-27 year	-5.0000*	**.000**	-6.84	-3.16
18-22 year	8-12 year	1.0300	.444	-.81	2.87
	13-17 year	.5100	.878	-1.33	2.35
	23-27 year	-4.4900*	**.000**	-6.33	-2.65
23-27 year	8-12 year	5.5200*	**.000**	3.68	7.36
	13-17 year	5.0000*	**.000**	3.16	6.84
	18-22 year	4.4900*	**.000**	2.65	6.33

17 (a) Effect of advancement of age on mean of decrease in velar length (mm) and (b) Comparison of the study population's age group and decrease in velar length (mm) in the NON-DYSLALIC group

Decrease in Velar length	8-12 year		13-17 year		18-22 year		23-27 year		P - value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	8.40	3.05	2.40	1.54	4.82	2.18	10.08	1.85	**0.000**

Tukey's multiple comparisons test		Mean Difference (I-J)	Sig.	95% Confidence Interval	
(I)	(J)			Lower Bound	Upper Bound
8-12 year	13-17 year	6.0000*	**.000**	3.31	8.69
	18-22 year	3.5778*	**.007**	0.81	6.34
	23-27 year	-1.6800	.347	-4.37	1.01
13-17 year	8-12 year	-6.0000*	**.000**	-8.69	-3.31
	18-22 year	-2.4222	.103	-5.19	0.34
	23-27 year	-7.6800*	**.000**	-10.37	-4.99
18-22 year	8-12 year	-3.5778*	**.007**	-6.34	-0.81
	13-17 year	2.4222	.103	-0.34	5.19
	23-27 year	-5.2578*	**.000**	-8.02	-2.49
23-27 year	8-12 year	1.6800	.347	-1.01	4.37
	13-17 year	7.6800*	**.000**	4.99	10.37
	18-22 year	5.2578*	**.000**	2.49	8.02



Graph 12 Showing the decrease in mean of Velar length at (mm) among subgroups of study population at different age groups

Among 20 patients in each age groups further subdivided into 10 patients in each subgroups viz. dyslalics and non dyslalics, studied that there is a statistically significant difference **(p value < 0.05)** in DYSLALIC & NON DYSLALIC of decrease in velar length (mm) at each age groups. In dyslalics, decrease in mean of velar length were 1.98 +/- 1.31 mm, 2.50 +/- 1.40 mm, 3.01 +/- 1.79 mm and 7.50 +/- 1.56 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. In non dyslalics, velar thickness while phonation were 8.40 +/- 3.05 mm, 2.40 +/- 1.54 mm, 4.82 +/- 2.18 mm and 10.08+/- 1.85 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively.

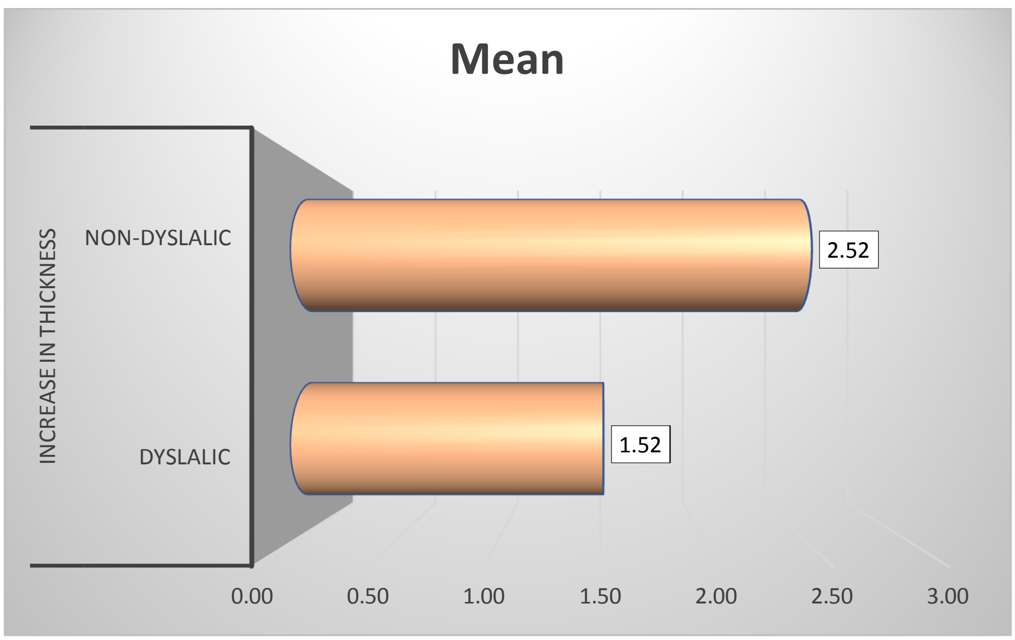
B. DECREASE IN VELAR THICKNESS [VELAR LENGTH AT REST – VELAR LENGTH WHILE PHONATION]

Table: 18 Comparison between mean of increase in velar thickness among Subgroups of study population

Increase in Velar thickness	**DYSLALIC**		**NON-DYSLALIC**		**P - value**
	Mean	**Standard Dev.**	**Mean**	**Standard Dev.**	
	1.52	0.99	2.52	1.25	**0.000**

Graph 13 Showing the increase in velar thickness among Subgroups of study population

A.



Among 80 patients, studied that there is a statistically significant difference **(p value < 0.05)** between DYSLALIC & NON DYSLALIC of increase in velar thickness.

Table: 19 (a) Effect of advancement of age on mean of increase in velar thickness (mm) and (b) Comparison of the study population's age group and increase in velar thickness (mm) in the DYSLALIC group

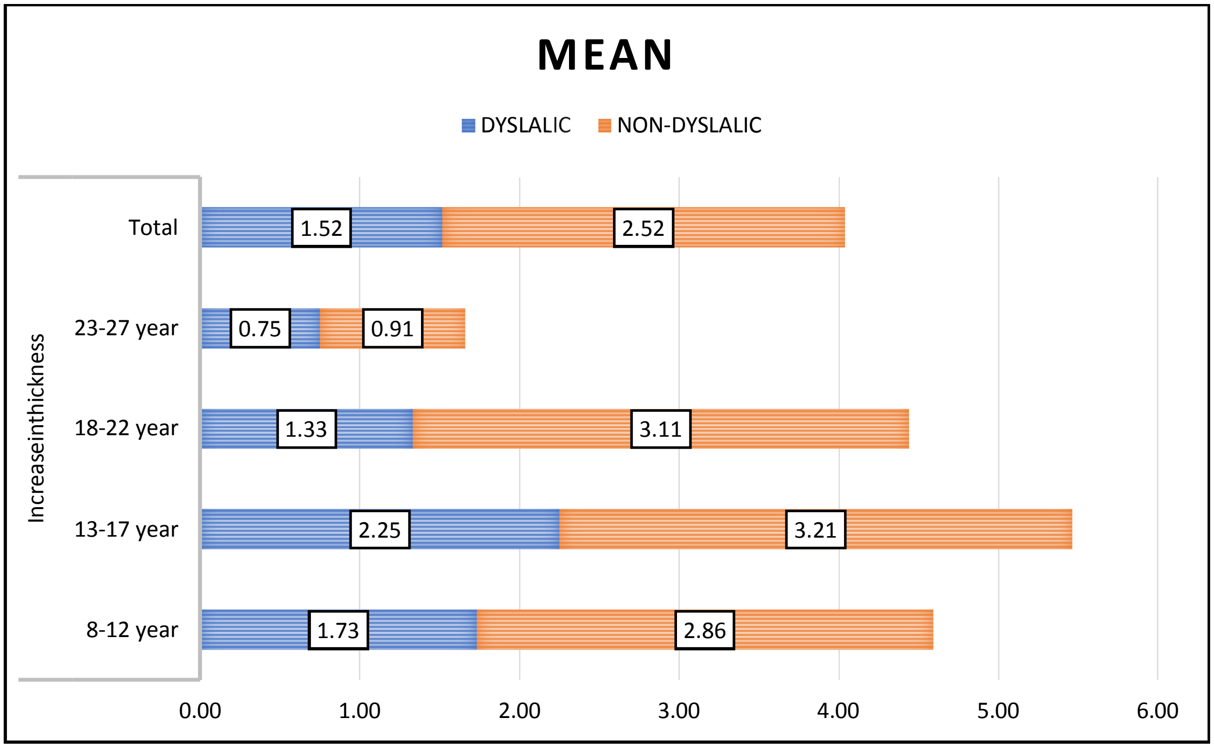
Increase in Velar thickness	8-12 year		13-17 year		18-22 year		23-27 year		P - value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	1.73	0.67	2.25	1.25	1.33	0.83	0.75	0.46	**0.003**

Tukey's multiple comparisons test		Mean Difference (I-J)	Sig.	95% Confidence Interval	
(I)	(J)			Lower Bound	Upper Bound
8-12 year	13-17 year	-.5200	.532	-1.55	.51
	18-22 year	.4000	.723	-.63	1.43
	23-27 year	.9800	.067	-.05	2.01
13-17 year	8-12 year	.5200	.532	-.51	1.55
	18-22 year	.9200	.094	-.11	1.95
	23-27 year	1.5000*	**.002**	.47	2.53
18-22 year	8-12 year	-.4000	.723	-1.43	.63
	13-17 year	-.9200	.094	-1.95	.11
	23-27 year	.5800	.438	-.45	1.61
23-27 year	8-12 year	-.9800	.067	-2.01	.05
	13-17 year	-1.5000*	**.002**	-2.53	-.47
	18-22 year	-.5800	.438	-1.61	.45

Table 20 (a) Effect of advancement of age on mean of increase in velar thickness (mm) and (b) Comparison of the study population's age group and increase in velar thickness (mm) in the NON-DYSLALIC group

Increase in Velar thickness	8-12 year		13-17 year		18-22 year		23-27 year		P - value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	2.86	0.90	3.21	0.91	3.11	1.09	0.91	0.24	**0.000**

Tukey's multiple comparisons test		Mean Difference (I-J)	Sig.	95% Confidence Interval	
(I)	(J)			Lower Bound	Upper Bound
8-12 year	13-17 year	-.3500	.795	-1.37	0.67
	18-22 year	-.2500	.912	-1.27	0.77
	23-27 year	1.9500*	**.000**	0.93	2.97
13-17 year	8-12 year	.3500	.795	-0.67	1.37
	18-22 year	.1000	.994	-0.92	1.12
	23-27 year	2.3000*	**.000**	1.28	3.32
18-22 year	8-12 year	.2500	.912	-0.77	1.27
	13-17 year	-.1000	.994	-1.12	0.92
	23-27 year	2.2000*	**.000**	1.18	3.22
23-27 year	8-12 year	-1.9500*	**.000**	-2.97	-0.93
	13-17 year	-2.3000*	**.000**	-3.32	-1.28
	18-22 year	-2.2000*	**.000**	-3.22	-1.18



Graph 14 Showing the decrease in mean of Velar thickness (mm) among subgroups of study population at different age groups

Among 20 patients in each age groups further subdivided into 10 patients in each subgroups viz. dyslalics and non dyslalics, studied that there is a statistically significant difference **(p value < 0.05)** in DYSLALIC & NON DYSLALIC of increase in velar thickness (mm) at each age groups. In dyslalics, increase in mean of velar thickness were 1.73 +/- 0.67 mm, 2.25 +/- 1.25 mm, 1.33 +/- 0.83 mm and 0.75 +/- 0.46 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. In non dyslalics, increase in mean of velar thickness were 2.86 +/ 0.90 mm, 3.21 +/- 0.91 mm, 3.11 +/- 1.09 mm and 0.91+/- 0.24 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively.

Dyslalia is a language disorder that affects a person's ability to articulate words correctly. Symptoms of dyslalia include difficulties with speech expression, mispronunciation of certain syllables, and stuttering. Speaking may be slow and hesitant, and the person may have difficulty emphasizing certain sounds or be unable to produce them at all. The diagnosis of Dyslalia is obtained through history, physical exam, assessment of speech production, imaging, and instrumental evaluation. Imaging techniques include Video-nasal Endoscopy, Nasal Endoscopy, Multiview Videofluoroscopy, Cephalometrics and Magnetic Resonance Imaging (MRI). (39) In the present study, we have used Modified Informal assessment method of phonation by Felicia Gironda and Renee Fabus to select dyslalic individuals and subjected them to digital lateral cephalometric technique to establish its efficacy as a tool for its early diagnosis.

In the present study, there was an assessment of velar length, thickness and difference in both these parameters while retraction seen during phonation in velum in different age groups. In addition, it was aimed towards finding a positive correlation with possibility of disorder of dyslalia.

Owing to deficiency of published research literature on velar retraction/stretch in general and in Indian population in specific and absence of its correlation with dyslalia, lead us to conduct this study. A total of 80 subjects were taken for this study, progressively over a time period, from those reporting the outpatient department for orthodontic treatment.

Among 80 patients included in the present study, we placed 20 patient under each age groups (8-12 years, 13-17 years, 18- 22 years and 23-27 years) and equally distributed to both subgroup i.e. dyslalics and non dyslalics. Further, among the subgroups 5 patients selected were males & 5 were females. **(TABLE 1-2) Mahdi Al-Dujailyet. al. (2015)** [40] and **Evgenija Grigorova (2020)** [41] reported articulation disorder are prevalent in age group of 4-6 years followed by 7-9 years since no study has been done beyond this age group and as any pathology can occur at any age group thus we choose a wide age range from 8 years to 27 years. In addition, we also aimed to assess the age changes and their effects on dyslalia.

In absence of adequate literature or researches regarding comparative evaluation of velum while phonation in dyslalics and non dyslalics in specific and other oral structures in general, we have tried to put forth possible explainations behind the below findings in our study.

In the present study, we took 80 digital lateral cephalogram at rest position (i.e. in no phonation) in individuals in accordance with our designed sample. Firstly, the velar length at rest was assessed in dyslalics and non dyslalics. Velar length is the linear distance measured from posterior nasal spine of hard palate to tip of uvula. On comparing its mean value between dyslalics and non dyslalics, it is significantly higher in dyslalics with mean of 36.18 +/- 5.43 as compared to 33.41 +/- 4.69 in non dyslalics. **(TABLE 3)**

This higher velar length at rest could be attributed to problem of habitual placement of tongue slightly in a forward position by dyslalics as compared to non dyslalics. This forward placement of tongue would lead to increased upper airway space as evident in tongue retaining devices. [42] This could possibly results in lengthening of velum to compensate the increased airway space and bring approximation of it which is key feature of velopharyngeal mechanism while phonation. [8]

Further, the mean of velar length at rest in different age groups of study sample has shown a significant increase in both dyslalics and non dyslalics with p-value 0.000 in both and a linear pattern is observed i.e. as age is increasing; velar length is also increasing**. (TABLE 4-5)** In dyslalics, velar length at rest were 28 +/- 0.78 mm, 34.66 +/- 2.20 mm, 40.25 +/- 1.22 mm and 41.43 +/- 1.38mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. In non dyslalics, velar length at rest were 28.42 +/- 1.21 mm, 31.17 +/- 1.30 mm, 34.44 +/- 2.96 mm and 39.59 +/- 2.58mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively.

This is in agreement with **Johnston and Richardson's (1999)** [43] cephalometric study of 16 young adults over a 32-year period showing that the soft palate lengthened and thickened over time and indicated towards hypothesis that pharyngeal structures can be dynamic throughout life and that adults tend to have longer and thicker soft palates than those of children and adolescents. Further, the findings in our present study are also in agreement with the findings in studies done by **Guttal et. al.(2012)** [44] and **V Deepa et. al.(2013)** [45], **Khaitan T. et. Al. (2015)**[46] , **Santosh et. al. (2015)** [47],and **Jamie L. Perry et. al. (2019)** [48].

On contrary, in a study done by **C Vani et al (2017)** [49] in which she had taken a sample size of 150 patients between age ranged from 20 to 70 years and had categorized them into 5 groups for assessing the morphology of soft palate and it's relation with age. Result showed no correlation between soft palate and age and reported this phenomenon due to the less sample size taken.

Further, a comparison of velar length at rest separately for dyslalics and non dyslalics during all age groups was made. **(FIGURE 4)** Apparently, it is higher in non dyslalics till the age of 17 years. Further, it is found to be greater in dyslalics in age groups from 18 years. In dyslalics, this increase is found to be around 6mm, 6mm and 1mm while in non-dyslalics, it is around only 3mm, 3mm, 5mm from age groups of 8-12 years to 13-17 years, 13-17 years to 18-22 years and 18-22 years to 23-27 years respectively.

This finding is in accordance with a cephalometric study done by **Taylor et. al. (1996)** [50] with 32 subjects with age group of 6 to 18 years every 3 years, and showed the soft palate increase by 1 mm in length and 0.5 mm in thickness every 3 years after age 9. Another study with similar parameters and in accordance with our study was carried out by **Priyal Agrawal et. al. (2016).** [51] They evaluated the differences in the form of soft palate and its related correlation to Need's ratio, Velar Length, Velar Width, and Pharyngeal Depth in age groups and genders via 121 CBCT scans in the Central Madhya Pradesh population from individuals aged from 15 to 45 years. Mean of velar length showed significant increase in age groups 15-20 yrs, 20-25yrs, 25-30yrs, 30-35 yrs, 35-40yrs, 40-45 yrs (32.68, 33.53, 35.60, 35.22, 35.86 and 38.30 mm respectively).. In another similar study using midsagittal anatomical magnetic resonance images (MRI) by **Kazlin N. Mason (2016)** [52], velar length was noted to increase with increase in age.

A higher rate of increase of velar length can be seen in dyslalics. With the advancement of age, the problem of increasing upper airway space might be worsening in later stages which could be possible reason for greater increase in velar length with age in dyslalics and at a faster pace.

Now, same 80 patients were asked to produce sound ‘sh’ and subsequent digital lateral cephalogram was taken. Firstly, assessment of the velar length while phonation was assessed. On comparing velar length while phonation between dyslalics and non dyslalics, it showed significantly higher values in dyslalics with mean of 32.46 +/- 4.34 as compared to 26.98 +/- 4.23 in non dyslalics. **(TABLE 6)** It was evident in our study that velar length at rest is higher in dyslalics and that becomes obvious reason for its proportioned higher values while phonation as well.

Further, mean of velar length while phonation presents significant difference with increase in age in both dyslalics and non dyslalics. **(TABLE 7-8)** In dyslalics, velar length while phonation were 26.41 +/- 1.34 mm, 32.27 +/- 2.31 mm, 37.24 +/- 2.18 mm and 33.93 +/- 1.13 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. In non dyslalics, velar length while phonation were 20.50 +/- 2.13 mm, 28.77 +/- 1.17 mm, 29.15 +/- 2.54 mm and 29.51 +/- 1.64 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. A linear pattern is observed in non dyslalics, that is with advancement of age, velar length while phonation is increasing. However, while phonation; non linear pattern is displayed in dyslalics. Increase in velar length in first three age groups (8-12yrs, 13-17yrs, 18-22yrs) is followed by its decrease in 4^{th} age group (23-27yrs).

This could be related to additional age related changes in surrounding adjacent structures which come in approximation while sound production causing nullifying effect on increased upper airway space. One such phenomenon to be mentioned is fat deposition leading to decreasing airway space and this is happening post this age group which is mentioned in obstructive sleep apnea studies as well. [53]

In present study, velar thickness assessment was made from digital lateral cephalogram at rest as well as of phonation position. Velar thickness is the linear distance of the thickest portion of the velum. Firstly, on comparing velar thickness at rest between dyslalics and non dyslalics, it is significantly lower in dyslalics with mean of 8.77 +/- 1.41 as compared to 9.55 +/- 1.86 in non dyslalics. **(TABLE 9)**

Owing to larger airway space in dyslalics, more stretch in musculature of soft palate is observed. The human oropharyngeal muscles have a unique anatomy with diverse and intricate functions. While other muscles (for eg. Limb muscles) shows immunoreaction for a panel of antibodies directed against different domains of cytoskeletal proteins desmin and dystrophin, a subpopulation of palate muscle fibers (two human palate muscles, musculus uvula (UV) and musculus palatopharyngeus (PP)) lacks or had a faint immunoreaction for desmin and the C□terminal of the dystrophin molecule which makes them more susceptible towards destruction followed by decreased thickness while excessive stretch. [54]

Further, mean of velar thickness at rest in age group with a difference of five years has shown a significant increase in linear pattern in both dyslalics and non dyslalics i.e. as age increases; velar thickness also increases. **(TABLE 10-11)** In dyslalics, velar thickness at rest were 8.31 +/- 0.95 mm, 8.41 +/- 1.14 mm, 8.84 +/- 2.25 mm and 9.52 +/- 0.63 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively.) In non dyslalics, velar thickness at rest were 7.69 +/- 1.29 mm, 9.82 +/- 1.26 mm, 9.97 +/- 2.30 mm and 10.70+/- 0.89 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively.

In a similar study by **Priyal Agrawal et. al. (2016)** [51] aiming to investigate the variation in morphology of soft palate and to find its association with the Need's ratio, Velar Length (VL), Velar Width (VW) and Pharyngeal Depth (PD), in age groups and gender using CBCT in Central Madhya Pradesh population with study sample consisting of 121 CBCT scans of individuals aged between 15 to 45 years was chosen. Mean of velar thickness showed significant increase in age groups 15-20 yrs, 20-25yrs, 25-30yrs, 30-35 yrs, 35-40yrs, 40-45 yrs were 9.03, 9.11, 8.71, 9.92, 8.89 and 10.09 respectively. This is in accordance with present study.

Contrary to our observation, a study was done by **Kruthika S Gutthal et.al. (2012)** [55] in which she had taken 200 digital lateral cephalogram age ranged from 15 to 30. Result showed the velar thickness a mean value of 7.68 +/- 2.01, with no corelation found between the age specific and the width of the soft palate. Width was highest in 26 - 30 years group, followed by 21 - 25 years, and 30 years and above group.

In our study, from digital lateral cephalogram taken while production of sound 'sh' is used to assess and compare velar thickness. In present study comparing between dyslalics and non dyslalics, it showed significantly lower values in dyslalics with mean of 10.13 +/- 1.25 as compared to 11.92 +/- 2.00 in non dyslalics. **(TABLE 12)** Velar thickness while rest was lower in dyslalics in our study, thus pattern of lower values in dyslalics while phonation follows the trend.

Further, mean of velar thickness while phonation presents difference with increase in age is significant in non dyslalics and insignificant in dyslalics. **(TABLE 13-14)** In dyslalics, velar thickness while phonation were 10.04 +/- 1.14 mm, 10.04 +/- 1.02 mm, 10.17 +/-

1.89 mm and 10.27 +/- 0.90 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. In non dyslalics, velar thickness while phonation were 10.55 +/- 1.07 mm, 13.03 +/- 1.07 mm, 12.62 +/- 3.17 mm and 11.49+/- 0.90 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. Additionally, unlike velar thickness at rest, while speech production non linear pattern is displayed in non dyslalics. Increase in velar thickness from age groups 8-12yrs to 13-17yrs is followed by its decrease in following two age groups. (18 to 22 yrs and 23 to 27yrs).

This finding could be related to additional age related changes happening in adjacent structures mentioned earlier while explaining decrease in velar length after a specific age group and justifies our hypothesis.

Lastly, the differences made in parameter of velar length and velar thickness in its retracted position (seen during phonation) from its position of rest are calculated in dyslalics as well as non dyslalics.

Difference in velar length (velar length at rest- velar length while speech production of 'sh') is calculated first and we observed a decrease in velar length while phonation in our study. **(TABLE 15-17)** In a similar study by **Arthur P. Mourino and Bernd Weinberg (1975),** [56] radiographic cephalometry was used to examine the prevalence of velar stretch in normal 8 and10-year-old children. In the study, it was observed that 90% of the children showed velar stretch when producing /u/ and 80% when producing /s/. Furthermore, all of the 10-year-old boys studied exhibited stretch during both productions, while 10-year-old girls had 100% and 90% stretch respectively. Additionally, 8-year-old children had 80% and 70% velar stretch for /u/ and /s/

respectively. However, velar retraction was registered during 10 of the 80 radiographic observations as the length of soft palate was less than its resting length during speech.

However, our study is in contradiction with similar studies done by **Graber et. al., Bzoch**, **Pruzansky and Mason**, **Simpson and Austin (1972)** [38] who suggested that there is a relevant increase in length of the soft palate when its in functional status as compared to resting position.

On comparing mean of decrease in velar length between dyslalics and non dyslalics, it showed significantly lower values in dyslalics with mean of 3.75 +/- 2.67 as compared to 6.47 +/- 3.74 in non dyslalics. Further, mean of decrease in velar length with sound production in age group with a difference of five years is observed and has shown a significant difference. In dyslalics, decrease in mean of velar length were 1.98 +/- 1.31 mm, 2.50 +/- 1.40 mm, 3.01 +/- 1.79 mm and 7.50 +/- 1.56 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. In non dyslalics, velar thickness while phonation were 8.40 +/- 3.05 mm, 2.40 +/- 1.54 mm, 4.82 +/- 2.18 mm and 10.08+/- 1.85 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. It is higher in non-dyslalics in almost all age groups. As age advanced, in non dyslalics, the pattern was non-linear and showed decrease followed by increase and warrant further research. Conversely, a linear pattern is evident in increase in difference of velar length in dyslalics with sharp increase seen in age group 23-27 years. The sharp increase in difference in velar length is also evident in non-dyslaslics in same age group. This is impacted by the decrease seen earlier in velar length while phonation in age group of 23-27 years in both dyslalics and non dyslalics in our study.

Finally, difference in velar thickness (velar thickness at rest- velar thickness while speech production of ‘sh’) is calculated and we observed a increase in velar thickness while phonation in our study **(TABLE 18-20)** A similar study was done by **Simpson and Austin (1972)**[38] which evaluated anterior portion of the velum and posterior portion of velum separately. They concluded that anterior portion got shorter in comparison to rest by 3.6 mm (41.6%), whereas the posterior portion experienced a prolongment of 2.5 mm (54.3%) and the frontal area decreased widthwise and the rear section extended along with expanding in thickness. However, through our study, taking velum as whole unit, decrease in velar length and increase in velar thickness can be evident giving a third angle to these calculations.

On comparing mean of increase in velar thickness between dyslalics and non dyslalics, it showed significantly lower values in dyslalics with mean of 1.52 +/- 0.99 as compared to 2.52 +/- 1.25 in non dyslalics. In the present study, mean of increase in velar thickness while sound production in age group with a difference of five years has shown a significant difference. In dyslalics, increase in mean of velar thickness were 1.73 +/- 0.67 mm, 2.25 +/- 1.25 mm, 1.33 +/- 0.83 mm and 0.75 +/- 0.46 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. In non dyslalics, increase in mean of velar thickness were 2.86 +/ 0.90 mm, 3.21 +/- 0.91 mm, 3.11 +/- 1.09 mm and 0.91+/- 0.24 mm in age group 8-12, 13-17, 18-22 and 23-27 years respectively. However, as age advanced, this pattern was non-linear and showed increase followed by decrease in later two age groups which is in confluence with the pattern shown in velar thickness while sound production.

This is preliminary study to compare velar changes between dyslalics and non dyslalics. In view of the above observations, further research with other structures of velopharyngeal apparatus in dyslalics and non dyslalics is required to get complete understanding of differences in the two groups.

Dyslalia is a speech disorder characterized by difficulty in pronouncing words, syllables, or letter sounds properly. There are many different types of dyslalia, from mild to severe. People with this disorder may have difficulty making certain sounds, mispronounce words, omit sounds, substitute sounds, or struggle to combine different sounds together.

Symptoms of dyslalia may include the following: inability to pronounce certain sounds such as th, s, z, sh; replacing one sound with another, such as replacing "k" with "t"; difficulty in articulating words and sentences; difficulty in expressing thoughts; and difficulty following instructions.

Dyslalia can be caused by a variety of factors, including hearing impairments, incorrect articulation patterns, muscle weakness, and brain or nerve damage. It can also be due to the influence of a foreign language or the influence of a dialectal language spoken in the same household. It can sometimes be the result of a learning disability, such as dyslexia.

Treatment for dyslalia includes speech therapy, articulation therapy, and listening training. Additionally, the affected individual can practice speaking with a mirror as a tool to help self-correct articulation errors. Ultimately, the purpose of treatment is to improve the person’s ability to communicate by self-monitoring their speech and correcting errors. Selective mutism and cluttering are two other speech disorders similar to dyslalia. With selective mutism, the individual is unable to speak in certain situations, and in cluttering, the individual speaks quickly and with a lot of breaks and hesitations.

If a person is suspected to have a disorder such as dyslalia, it is important to get them evaluated by an experienced therapist as soon as possible. Early intervention can help minimize the language difficulties and improve a person's ability to communicate with others. In view of this aim, we have tried to establish usefulness of lateral cephalogram in evaluation of dyslalia.

In this study, a total of 160 lateral cephalographs were taken on 80 patients, which consisted of 40 dyslalics and 40 non dyslalics in age range 8-27 years. Four variables were measured by Planmeca Romexis 2.9.2.R software, the four parameters are velar length at rest, velar length while phonation, velar thickness while rest and velar thickness while phonation.

Preliminary data from this study suggests all the four parameters along with their difference while rest and phonation to show statistically significant increase with increase in age in both dyslalics and non dyslalics. In addition, these values showed significant difference between dyslalic and non dyslalic groups. Further, study is needed to test the hypothesis of the relationship of velar parameters during speech along with adjacent structures impacting the age related changes from age 13 to 22 years and beyond and its effect to speech.

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ANNEXURE-1
CASE HISTORY SHEET

DEPARTMENT OF ORAL MEDICINE AND RADIOLOGY

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES, LUCKNOW

CASE NO. FILE NO. DATE:

NAME: AGE: GENDER:

OCCUPATION: MARITAL STATUS:

ADDRESS:

CONTACT NO:

CHIEF COMPLAINT:

HISTORY OF PRESENT ILLNESS:

PAST MEDICAL AND SURGICAL HISTORY:

COVID VACCINATION:

DRUG ALLERGY:

PAST DENTAL HISTORY:

FAMILY HISTORY:

PERSONAL HISTORY:

SPEECH EXAMINATION

1. WORDLESS PICTURE BOOK:

TOTAL ‘SH’ WORDS =

TOTAL WORDS SPOKEN CORRECTLY =

2. PASSAGE:

TOTAL ‘SH’ WORDS =

TOTAL WORDS SPOKEN CORRECTLY =

3. NEWSPAPER:

TOTAL ‘SH’ WORDS =

TOTAL WORDS SPOKEN CORRECTLY =

4. FINAL INTELLIGIBILITY PERCENTAGE =

(INTELLIGIBILITY PERCENTAGE = NO. OF ‘SH’ SOUND WORDS SPOKEN CORRECTLY * 100 / NO. OF TOTAL WORDS WITH ‘SH’ SOUND INCLUDED IN SAMPLE)

RADIOGRAPHIC EXAMINATION

- LATERAL CEPHALOGRAPH:
  1. LENGTH OF VELUM-
  2. THICKNESS OF VELUM-

STUDENT SIGNATURE STAFF SIGNATURE

ANNEXURE 2 (A)

Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

Consent Form (English)

Title of the Study ………..
Study Number……..
Subject's Full Name……….
Date of Birth/Age ………
Address of the Subject…………………….
Phone no. and e-mail address………………
Qualification ………………………………
Occupation: Student / Self Employed / Service /
Housewife/Other (Please tick as appropriate)
Annual income of the Subject………………
Name and of the nominees(s) and his relation to the subject.......................(For the purpose of compensation in case of trial related death).

1. I confirm that I have read and understood the Participant Information Document dated
……..for the above study and have had the opportunity to ask questions. **OR**
I have beenexplained the nature of the study by the Investigator and had the opportunity to ask questions.
2. I understand that my participation in the study is voluntary and given with free will without any duress and that I am free to withdraw at any time, without giving any reason and without my medical care or legal rights being affected.
3. I understand that the sponsor of the project, others working on the Sponsor's behalf, the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. However, I understand that my Identity will not be revealed in any information released to third parties or published.
4. I agree not to restrict the use of any data or results that arise from this study provided sucha use is only for scientific purpose(s).
5. I permit the use of stored sample (tooth/tissue/blood) for future research. **Yes [ ] No [ ] Not Applicable [ ]**
6. I agree to participate in the above study. I have been explained about the complications andside effects, if any, and have fully understood them. I have also read and understood the participant/volunteer's Information document given to me.

Signature (or Thumb impression) of the Subject/Legally AcceptableRepresentative:……………..
Signatory's Name……………. Date ……….
Signature of the Investigator………………… Date………..
Study Investigator's Name.......................... Date………..
Signature of the witness…………………… Date………..
Name of the witness…………………………

Received a signed copy of the PID and duly filled consent form Signature/thumb impression of the subject or legally Acceptable representative

Date:………………………

ANNEXURE 2B

Babu Banarasi Das College of Dental Sciences

(Babu Banarasi Das University)

BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

सहमति पत्र

अध्ययन
शीर्षक———————————————————————————————
अध्ययन संख्या
प्रतिभागी के पूर्ण नाम ————————————————————————
जन्म तिथि/आयु—————————————————————————
प्रतिभागी का पता ————————————————————————
फोन नं और ईमेल पता ———————————————————————
योग्यता ———————————————————————————
व्यवसायः छात्र/स्वं कार्यरत / सेवा / ग्रहिणी————————————
अन्य (उचित रुप मे टिक करें) ————————————————————
प्रतिभागी की वार्षिक आय ——————————————————————
प्रत्याषीयो के नाम और प्रतिभागी से संबंध... (परीक्षण से संबंधित मौत के मामले मे मुआवजे के प्रयोजन के लिए)

1. मेरी पुष्टि है कि मैने अध्ययन हेतु सुचना पत्र दिनांक .... को पढ व समझ लिया तथा मुझे प्रश्न पुछने या मुझे अध्ययन अन्वेशक ने सभी तथ्यों को समझा दिया है तथा मुझे प्रश्न पुछने के समान अवसर प्रदान किए गये।

2. मैंने यहॉ समझ लिया कि अध्ययन में मेरी भागीदारी पूर्णतः स्वैच्छिक है और किसी भी दबाव के बिना स्वतंत्र इच्छा के साथ दिया है किसी भी समय किसी भी कारण के बिना , मेरे इलाज या कानूनी अधिकारो को प्रभावित किए बिना, अध्ययन में भाग न लेने के लिए स्वतंत्र हुँ ।

3. मैंने यह समझ लिया है कि अध्ययन के प्रायोजक , प्रायोजक की तरफ से काम करने वाले लोग, आचार समिति और नियामक अधिकारियों को मेरे स्वास्थ्य रिकार्ड को वर्तमान अध्ययन या आगे के अध्ययन के सन्दर्भ देखने के लिए मेरी अनुमति की जरूरत नही है, चाहे मैने इस अध्ययन से नाम वापस ले लिया है। हॉलाकि मै यह समझता हुँ कि मेरी पहचान को किसी भी तीसरे पक्ष या प्रकाषित माध्यम में नही दी जायेगी।

4. मै इससे सहमत हूॅ कि कोई भी डेटा या परिणाम जो इस अध्ययन से प्राप्त होता है उसका वैज्ञानिक उद्देष्य ;ओं) के उपयोग के लिए मेरी तरफ से कोई प्रतिबंध नही है।

5. भवि"य के अनुसंधान के लिए भंडारित नमूना (ऊतक/रक्त) पर अध्ययन के लिए अपनी सहमति देता हुँ।

हॉ **[ ]** नही **[ ]** अनउपयुक्त **[ ]**

6. मै परीक्षण की अनुमति देता हुँ। मुझे इसके द्वारा यदि कोई परेशानी होती है, इसके बारे में जानकारी दे दी गई है। मैने रोगी जानकारी सूचना पत्र को पढ तथा समझ लिया है।

हस्ताक्षरकर्ता का नाम..दिनांक..

अन्वेशक के हस्ताक्षर .... दिनांक ....

प्रतिभागी / कानूनी तौर पर स्वीकार्य प्रतिनिधि का हस्ताक्षर (या अंगूठे का निशान................

..

अध्ययन अन्वेशक का नाम ....

गवाह के हस्ताक्षर .... दिनांक ....

गवाह के नाम ....

मैनें पीआईडी और विधिवत भरे सहमति फार्म का एक हस्ताक्षर की नकल प्राप्त की

प्रतिभागी कानूनी तौर पर प्रतिनिधि का हस्ताक्षर/ अंगूठे का निशान ....

दिनांक...........................

ANNEXURE 3(A)

Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

Child Assent Form

Study Title ____

Study Number____

Subject's Full Name ____

Date of Birth/Age____

Address____

I____ _ _______, exercising my free power ofchoice, hereby give my consent for participation in the study entitled:

"……………………………………………………………...…………………"

I have been informed, to my satisfaction, by the attending physician, about the purpose of the study and the nature of the procedure to be done. I am aware that my parents/guardians do not have to bear the expenses of the treatment if I suffer from any trial related injury, which has causal relationship with the said trial drug. I am also aware of right to opt out of the trial, at any time during the course of the trial, without having to give reasons for doing so

Signature of the study participant_________________________Date:____________

Name of the study participant____

Signature of the Witness______________________________Date______________

Name of the Witness ______________________________

Signature of the attending Physician____________________Date:_____________

Name of the attending Physician

Babu Banarasi Das College of Dental Sciences

(Babu Banarasi Das University)

BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

शिशु सहमति पत्र

मैं————————————————————————————————————में भाग लेने के लिए

अपनी सहमति प्रदान करता हूँ। मुझे इस अध्ययन के हेतु और उसमे की जाने वाली प्रक्रिया के बारे में चिकित्सक द्वारा बता दिया गया है। मुझे पता है कि अध्ययन सम्बन्धी किसी हानि जिसका अध्ययन की दावा से सम्बन्ध है उसका खर्च मेरे माता पिता अथवा अभिवाहक को नहीं वहां करना है मुझे यह भी पता है कि मैं इस अध्ययन से किसी समय बिना कोई कारण बताये बाहर **DCOBS** हो सकता हूँ ।

अध्ययन में भाग लेने वाले का नाम और हस्ताक्षर

————————————दिनांक—————————

गवाह के हस्ताक्षर—————————————————— दिनांक——————————

गवाह का नाम————————————————————————————————————

चिकित्सक का नाम और हस्ताक्षर

——————————दिनांक——————

ANNEXURE 4

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES
(FACULTY OF BBD UNIVERSITY), LUCKNOW

INSTITUTIONAL RESEARCH COMMITTEE APPROVAL

The project titled **"Evaluation of Changes in Velar Stretch with Age and Correlating it with Possibility of Dyslalia: A Digital Cephalometric Study."** submitted by **Dr Swarnaa Chaturvedi** Post graduate student from the **Department of Oral Medicine & Radiology** as part of MDS Curriculum for the academic year 2020-2023 with the accompanying proforma was reviewed by the Institutional Research Committee present on **12th October 2021** at BBDCODS.

The Committee has granted approval on the scientific content of the project. The proposal may now be reviewed by the Institutional Ethics Committee for granting ethical approval.

Prof. Vandana A Pant
Co-Chairperson

Prof. B. Rajkumar
Chairperson

ANNEXURE 5

Babu Banarasi Das University
Babu Banarasi Das College of Dental Sciences,
BBD City, Faizabad Road, Lucknow – 226028 (INDIA)

Dr. Lakshmi Bala
Professor and Head Biochemistry and
Member-Secretary, Institutional Ethics Committee

Communication of the Decision of the IXth Institutional Ethics Sub-Committee

IEC Code: 35 **BBDCODS/04/2022**

Title of the Project: Evaluation of changes in velar stretch with age and correlating it with possibility of dyslalia: A digital cephalometric study.

Principal Investigator: Dr Swarnaa Chaturvedi **Department:** Oral Medicine & Radiology

Name and Address of the Institution: BBD College of Dental Sciences Lucknow.

Type of Submission: New, MDS Research

Dear Dr Swarnaa Chaturvedi,

The Institutional Ethics Sub-Committee meeting comprising following four members was held on 07th April, 2022.

1.	Dr. Lakshmi Bala Member Secretary	Prof. and Head, Department of Biochemistry, BBDCODS, Lucknow
2.	Dr. Amrit Tandan Member	Prof. & Head, Department of Prosthodontics and Crown & Bridge, BBDCODS, Lucknow
3.	Dr. Rana Pratap Maurya Member	Reader, Department of Orthodontics, BBDCODS, Lucknow
4.	Dr. Akanksha Bhatt Member	Reader, Department of Conservative Dentistry & Endodontics, BBDCODS, Lucknow

The committee reviewed and discussed your submitted documents of the current MDS Project Protocol in the meeting.
The comments were communicated to PI thereafter it was revised.

Decisions: The committee approved the above protocol from ethics point of view.

Forwarded by:

Lakshmi Bala

(Dr. Lakshmi Bala)
Member-Secretary
IEC

Member-Secretary
Institutional Ethic Committee
BBD College of Dental Sciences
BBD University
Faizabad Road, Lucknow-226028

(Dr. Puneet Ahuja)
Principal
BBDCODS

PRINCIPAL
Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow-226028

ANNEXURE 6

STASTICAL ANALYSIS FORMULAS

Arithmetic mean ($\bar{x}$)

Mean is one of the measures of central tendency. It finds the average value for the given data/observations. Arithmetic mean is defined as the sum of all the numbers in the data divided by the total count of numbers. The formula for finding the mean is given by,

$$\bar{x} = \frac{\sum x}{n}$$

Where $\sum$x is summation of all observations

n = Total number of observations

Standard Deviation (σ)

Standard deviation measures the amount of variation/dispersion of a set of values. Dispersion tells how much data is spread out. A lower standard deviation indicates that data is close to the center. The higher value of standard deviation represents that data spread is more.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

Standard Error

The standard error is one of the mathematical tools used in statistics to estimate the variability. It is abbreviated as SE. The standard error of a statistic or an estimate of a parameter is the standard deviation of its sampling distribution. We can define it as an estimate of that standard deviation.

Standard Error Formula

The accuracy of a sample that describes a population is identified through the SE formula. The sample mean which deviates from the given population and that deviation is given as.

$$SE_{\bar{x}} = \frac{S}{\sqrt{n}}$$

Where,

S is the standard deviation

n is the number of observation

P-Value

P-Value or probability value can be defined as the measure of the probability that a real-valued test statistic is at least as extreme as the value actually obtained.

The mentioned P in the text indicates the following:

P>0.05 – Not Significant

P<0.05 – Just significant (*)

P<0.01 – Moderately significant (**)

P<0.001 – Highly significant (***)

ANOVA

Analysis of Variance (**ANOVA**) is a statistical formula used to compare variances across the means (or average) of different groups. A range of scenarios use it to determine if there is any difference between the means of different groups.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares (MS)	F
Within	$SSW = \sum_{j=1}^{k}\sum_{j=1}^{l}(X-\bar{X}_j)^2$	$df_w = k-1$	$MSW = \frac{SSW}{df_w}$	$F = \frac{MSB}{MSW}$
Between	$SSB = \sum_{j=1}^{k}(\bar{X}_j-\bar{X})^2$	$df_b = n-k$	$MSB = \frac{SSB}{df_b}$	
Total	$SST = \sum_{j=1}^{n}(\bar{X}_j-\bar{X})^2$	$df_t = n-1$		

F = MST/MSE

MST = SST/ p-1

MSE = SSE/N-p

SSE = ∑ (n−1)

s2

Where,

F = Anova Coefficient

MSB = Mean sum of squares between the groups

MSW = Mean sum of squares within the groups

MSE = Mean sum of squares due to error

SST = total Sum of squares

p = Total number of populations

n = The total number of samples in a population

SSW = Sum of squares within the groups

SSB = Sum of squares between the groups

SSE = Sum of squares due to error

s = Standard deviation of the samples

N = Total number of observations

Tukey's multiple comparison test

Tukey's multiple comparison testis a single-step multiple comparison procedure and statistical test. It can be used to find means that are significantly different from each other.

Tukey's test is based on a formula very similar to that of the *t*-test. In fact, Tukey's test is essentially a *t*-test, except that it corrects for family-wise error rate.

The formula for Tukey's test is:

$$q_s = \frac{Y_A - Y_B}{SE}$$

where,

Y_A - Larger of the two means being compared,

Y_B - Smaller of the two means being compared, and

SE - Standard error of the sum of the means.

The q_s value can then be compared to a q value from the studentized range distribution. If the q_s value is *larger* than the critical value q_α obtained from the distribution, the two means aresaid to be significantly different at level $\alpha : 0 \leq \alpha \leq 1$

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Background Dyslalia, or difficulty in articulating words, is a speech disorder that can affect both children and adults. It is caused by a problem with the articulation of speech. This can make it difficult to correctly articulate words and sentences, which can lead to frustration or embarrassment. In order to diagnose and treat dyslalia, speech-language pathologists use various assessment tools. Application of cost effective diagnostic method like lateral cephalometric radiography would be a major breakthrough. Materials and Methods This study include 80 subjects from both genders between the age range of 8-27 years who were subjected to digital lateral cephalometric radiograph along with Modified Informal assessment method of phonation conducted at Department of Oral Medicine and Radiology. Result In the present study, the velar length, velar thickness and difference in velar length and velar thickness while rest and phonation between dyslalics and non dyslalics have been assessed and a significant difference has been observed. However, insignificant results are obtained in case of effect of age in velar thickness while phonation in dyslalics. Conclusion On comparing dyslalics and non dyslalics, the significant difference in velar length, velar thickness and their respective difference while rest and phonation which was evaluated through lateral cephalometric radiography could serve as a cost-effective method for diagnosing Dyslalia. However, comparative evaluation between dyslalics and non dyslalics and effect of age on other structures of velopharyngeal apparatus while phonation warrant further research. Keywords Dyslalia, Lateral cephalograph, Velar, Velar stretch, Velar retraction, Velum