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# ANALYSIS OF VARIATION IN VELAR MORPHOLOGY WITH ASSESSMENT OF NEED'S RATIO IN NORMAL INDIVIDUAL: A PROSPECTIVE CROSS-SECTIONAL DIGITAL CEPHALOMETRIC STUDY

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## ABSTRACT

**Background**: Soft palate is posterior fibromuscular part of the palate whose morphological variants in the past have been largely ignored until you et.al. classified the same. Soft palate dysfunctions are frequently seen in patients with cleft palate, oral submucous fibrosis, obstructive sleep apnoea, soft palate dysfunction. Hence knowledge of velar morphology and need's ratio helps us to approach and manage such conditions. **Aim**: The purpose of the present study was to investigate the variation in morphology of soft palate in different age and sex groups, and to find its association with the Need's ratio. **Materials and Methods**: The study sample consisted of 240 subjects aged between 15 and 45 years. The velar morphology on lateral cephalograms was analysed and grouped into different types. Need's ratio was calculated for all subjects by division of pharyngeal depth by velar length. The results obtained were subjected to a statistical analysis. **Results**: The most frequent type was rat tail shaped and least common distorted/S shaped. New variants were observed. The mean velar length and velar width, pharyngeal depth values were significantly higher in males while Need's ratio were higher among females. A highly significant association was observed between the mean velar width, pharyngeal depth, and need's ratio with various age groups. **Conclusion**: The present study highlighted to investigate the various morphological appearance of soft palate as described by You M et.al using lateral cephalograms. The knowledge of a varied spectrum of velar morphology and the variants of the soft palate helps in a better understanding of the velopharyngeal closure and craniofacial anomalies.

**KEYWORDS:** velar morphology, velopharyngeal insufficiency, lateral cephalogram, Need's ratio.

## INTRODUCTION

The velopharyngeal mechanism consists of a muscular valve that extends from the posterior surface of the hard palate (roof of mouth) to the posterior pharyngeal wall.[1] The function of the velopharyngeal mechanism is to create a tight seal between the velum and pharyngeal walls to separate the nasopharynx from the oropharynx and is often looked upon as traffic controller at the cross roads between the food and air passages.[1],[2] The primary functions of the soft palate can be enlisted as to aid deglutition, respiration, to maintain patency of the airway as well as the respiratory tract to prevent regurgitation and facilitate the pronunciation of velar consonants thereby playing important role in speech and phonetics.[3] In the study done by You et al, the morphological variations were classified into six types (Type 1: Leaf shaped; Type 2: Rat tail; Type 3: Butt like; Type 4: Straight line; Type 5: S-shaped and Type 6: Crook shaped).[4] Pepin et al, reported co-relation between the "Hooked or S-shaped" soft palate and that it indicated a high risk of the obstructive sleep apnoea syndrome.[5] In the study by Subtelny, Need's ratio is pharyngeal depth to velar length which ranges from 0.6 to 0.7 in normal population, and an increase in this ratio in the concern group may have a risk of VPI (Velopharyngeal incompetency).[6] Recently, in the juvenile population obstructive sleep apnoea has received attention. It has been suggested that upper airway patency while asleep is relevant to the craniofacial growth pattern as the child grows.[7] Knowledge of velar morphology and the variants of the soft palate help in a better understanding of the velopharyngeal closure, obstructive sleep apnoea and craniofacial anomalies. Dental surgeon can plan surgical

procedure related to velopharyngeal dysfunctions and avoid any complications arising from it.[8,9] Doctors who will be potential readers including orthodontists, pedodontists, oral and maxillofacial radiologist, Ent specialist, forensic analysis will benefit from our study. Thus the present study was done to investigate the variation in morphology of soft palate in different age and sex groups, and to find its association with the Need's ratio.

## MATERIALS AND METHODS

This study is complied with STROBE protocols.

This prospective observational study was conducted in Department of Oral Medicine & Radiology of our institute. 240 digital lateral cephalograms of normal subjects visiting the department were selected from April 2022 to July 2022. Patient's consent was obtained from each subject & ethical clearance was obtained from institutional ethics committee (CSMSS/DCH/PG/EC/SS/2022.03).

### Inclusion criteria

-Individuals within age group- 15 to 45 yrs.
-Healthy patients without cleft palate.

### Exclusion criteria

-Patients below 15 years and above 45 years of age
-Patients with palatal defects, undergoing palatal surgery and fractures of the head and neck.
-Patients with oral submucous fibrosis.

Total 240 participants were included in the study and divided into 6 age groups (15-20, 20-25, 25-30, 30-35, 35-40, 40-45). All the radiographs were analyzed and categorized into six types according to the soft palate morphology. The VL was evaluated by measuring the linear distance from the posterior nasal spine to the tip of the uvula of the resting soft palate (Fig.1a). The VW measurement was taken at the thickest section of the velum (Fig.1b). The PD was noted as a linear distance from the posterior surface of the nasal spine marker to the posterior pharyngeal wall along the palatal plane (Fig.1c). The measurements were carried out for each digital radiograph, saved in a JPG file format using ident software. The Need's ratio was calculated for all the subjects by the division of PD by VL.

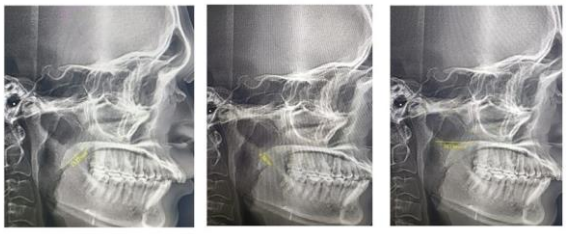


Figure 1 (a) Figure 1 (b) Figure 1 (c)

## SAMPLE SIZE ESTIMATION

Sample size was calculated using a openepi info software, version 3

To calculate the sample size for the present study the following formula was used.

Sample size $n$ = [DEFF xNp(1-p)]/ [$(d^2/Z^2_{1-\alpha/2}$x (N-1)+p x(1-p)]

Population size (for finite population correction factor or fpc) (*N*): 600

Hypothesized % frequency of outcome factor in the population (*p*): 35.5%±5

Confidence limits as % of 100(absolute ± %) (*d*): 5%

Design effect (for cluster surveys-*DEFF*): 1

Substituting the values in the formula, a sample size of 223 was derived. However, an additional 10% was included in the study [N = 240.3 (rounded off to 240)] in order to compensate for potential refusals. The sample size of the present study was estimated to be 240 at 95% confidence interval.

## STATISTICAL ANALYSIS

Data entries was done in Microsoft Office Excel 2010 and analyses of results was done using Statistical product and service solution (SPSS) version 22 software. Descriptive statistics such as mean and standard deviation was calculated for quantitative variables. Percentage was used for representing qualitative variables. The p value was fixed at 0.05. Data normality was checked using Shapiro Wilk test. Pearson r correlation test was used for correlation of soft palate parameter with age groups. Chi square test was used for association between soft palate parameters and gender. Unpaired t test was used to compare soft tissue parameter between male and females. One way ANOVA f test was used for comparison between soft tissue parameter between different age group categories.

## RESULTS

Six types of velar morphologies were traced by observing the image of the velum on lateral cephalograms.

- Type 1: 'Leaf shape' lanceolate, indicated that the middle portion of the soft palate elevated to both the naso- and the oro-side.
- Type 2: 'Rat-tail shape' soft palate showed that the anterior portion was inflated and the free margin had an obvious coarctation.
- Type 3: A 'butt-like' soft palate with a shorter and fatter velum appearance, and the width had almost no distinct difference from the anterior portion to the free margin.
- Type 4: 'Straight line shape'.
- Type 5: The distorted soft palate, presented the S-shape.
- Type 6: 'Crook' appearance of the soft palate, in which the posterior portion of the soft palate crooks anteriosuperiorly.[8]
- Type 7: Variants which did not fit into either of the aforementioned categories

Bifid-shaped soft palate (3 cases) found in 15-20 (F), 40-45 (M) & 40-45 (F) age groups

**Table 1: Distribution and correlation of soft palate type with age groups.**

| Age | Type 1 N (%) n = 59 | Type 2 N (%) n = 95 | Type 3 N (%) n = 36 | Type 4 N (%) n = 29 | Type 5 N (%) n = 1 | Type 6 N (%) n = 14 | Type 7 N (%) n = 6 |
|---|---|---|---|---|---|---|---|
| 15-20 years | 8 (20%) | 18 (45%) | 5 (12.5%) | 3 (7.5%) | 0 (0%) | 3 (7.5%) | 3 (7.5%) |
| 20-25 years | 11 (27.5%) | 11 (27.5%) | 7 (17.5%) | 9 (22.5%) | 0 (0%) | 1 (2.5%) | 1 (2.5%) |
| 25-30 years | 6 (15%) | 15 (37.5%) | 7 (17.5%) | 7 (17.5%) | 0 (0%) | 4 (10%) | 1 (2.5%) |
| 30-35 years | 9 (22.5%) | 19 (47.5%) | 6 (15%) | 4 (10%) | 0 (0%) | 2 (5%) | 0 (0%) |
| 35-40 years | 13 (32.5%) | 18 (45%) | 1 (2.5%) | 6 (15%) | 0 (0%) | 1 (2.5%) | 1 (2.5%) |
| 40-45 years | 12 (30%) | 14 (35%) | 10 (25%) | 0 (0%) | 1 (2.5%) | 3 (7.5%) | 0 (0%) |
| Pearson 'r' correlation coefficient | 0.945 | 0.983 | 0.971 | 0.993 | 0.946 | 0.968 | 0.952 |
| P value | 0.945 | 0.983 | 0.971 | 0.993 | 0.946 | 0.968 | 0.952 |
| ***p<0.001-highly significant* | | | | | | | |

New variants were added to morphological types of soft palate which was observed in all age groups except 30-35 group and 40-45 group. Type 2 was most prevalent in all age groups. There was highly significant correlation noted among age groups and types of soft palate. (Table 1).

**Table 2: Distribution and correlation of soft palate type with gender.**

| Gender | Type 1 N (%) n = 59 | Type 2 N (%) n = 95 | Type 3 N (%) n = 36 | Type 4 N (%) n = 29 | Type 5 N (%) n = 1 | Type 6 N (%) n = 14 | Type 7 N (%) n = 6 |
|---|---|---|---|---|---|---|---|
| Male (n=120) | 36 (30%) | 33 (27.5%) | 23 (19.2%) | 18 (15%) | 1 (0.8%) | 6 (5%) | 3 (2.5%) |
| Female (n=120) | 23 (19.2%) | 62 (51.7%) | 13 (10.8%) | 11 (9.2%) | 0 (0%) | 8 (6.7%) | 3 (2.5%) |
| Chi square test | Chi = 19.2 | Chi = 15.4 | Chi = 12.9 | Chi = 18.2 | Chi = 2.4 | Chi = 0.8 | Chi = 0.45 |
| P value | P<0.001** | P<0.001** | P<0.001** | P<0.001** | P<0.001** | P<0.001** | P<0.001** |
| ***p<0.001-highly significant* | | | | | | | |

Among males most common type obtained was type 1 in 30% males and least common was type 4 in 0.8% males. Among females most common type obtained was type 2 in 51.7% and least common was type 5 in 0% females. Highly significant correlation was observed between gender and types of soft palate. Hence, we can conclude that gender determination can be done with respect to variation in types of soft palate (Table 2).

**Table 3: Comparison of mean velar length, velar width, pharyngeal depth and need's ratio with morphological types of soft palate.**

| | Type 1 N (%) n = 59 | Type 2 N (%) n = 95 | Type 3 N (%) n = 36 | Type 4 N (%) n = 29 | Type 5 N (%) n = 1 | Type 6 N (%) n = 14 | Type 7 N (%) n = 6 | P value |
|---|---|---|---|---|---|---|---|---|
| Velar Length | 36 (30%) | 33 (27.5%) | 23 (19.2%) | 18 (15%) | 1 (0.8%) | 6 (5%) | 3 (2.5%) | P= 0.001* |
| Velar Width | 23 (19.2%) | 62 (51.7%) | 13 (10.8%) | 11 (9.2%) | 0 (0%) | 8 (6.7%) | 3 (2.5%) | P<0.001** |
| Pharyngeal Depth | Chi = 19.2 | Chi = 15.4 | Chi = 12.9 | Chi = 18.2 | Chi = 2.4 | Chi = 0.8 | Chi = 0.45 | P=0.098 (NS) |
| Need's Ratio | P<0.001** | P<0.001** | P<0.001** | P<0.001** | P<0.001** | P<0.001** | P<0.001** | P= 0.001* |
| *p>0.05-no significance difference, *p<0.05- significant, **p<0.001-highly significant* | | | | | | | | |

The difference in velar length and need's ratio among different types of soft palate were statistically significant. The difference in velar width among different types of soft palate was highly significant. While difference in pharyngeal depth among different types of soft palate was not significant. Hence, concluding that types of soft palate can be identified by calculating velar length, velar width and need's ratio but soft palate types cannot be identified by calculation of pharyngeal depth (Table 3).

**Table 4: Comparison of Mean Velar Length, Velar Width, Pharyngeal Depth and Need's Ratio With Gender.**

| | Male (n = 120) | Female (n = 120) | P value |
|---|---|---|---|
| Velar Length | 25.52 (3.11) | 24.06 (3.73) | P= 0.001* |
| Velar Width | 5.96 (1.49) | 5.48 (1.39) | P= 0.01* |
| Pharyngeal Depth | 17.87 (8.59) | 17.1 (8.19) | P= 0.477 (NS) |
| Need's Ratio | 0.7 (0.34) | 0.71 (0.35) | P= 0.805 (NS) |
| *p>0.05-no significance difference, *p<0.05- significant, **p<0.001-highly significant* | | | |

Velar length and velar width were higher in males and difference was statistical significance. Pharyngeal depth was higher in males but difference was not statistically significant. Need's ratio was higher in females but difference is not significant. As velar length, velar width and pharyngeal depth is higher among males where as need's ratio is higher among females it was concluded that gender can be determined using velar length, velar width and pharyngeal depth and need's ratio (Table 4).

**Table 5: Comparison of mean velar length, velar width, pharyngeal depth and need's ratio with age groups.**

| | 15-20 years | 20-25 years | 25-30 years | 30-35 years | 35-40 years | 40-45 years | P value |
|---|---|---|---|---|---|---|---|
| Velar Length | 25.74 (3.58) | 25.67 (3.98) | 24.08 (3.24) | 24.61 (3.11) | 24.5 (4.29) | 24.13 (2.3) | P=0.113 |
| Velar Width | 6.31 (1.42) | 6.14 (1.82) | 5.49 (1.22) | 5.43 (1.02) | 5.03 (1.4) | 5.93 (1.41) | P<0.001** |
| Pharyngeal Depth | 21.2 (4.7) | 21.82 (2.68) | 19.75 (2.43) | 20.9 (2.17) | 0.0 (0.0) | 21.12 (3.5) | P<0.001** |
| Need's Ratio | 0.82 (0.17) | 0.85 (0.13) | 0.83 (0.15) | 0.86 (0.15) | 0.0 (0.0) | 0.88 (0.19) | P<0.001** |
| *p>0.05-no significance difference, *p<0.05- significant, **p<0.001-highly significant* | | | | | | | |

Decrease with small variation was noted in velar length with increasing age. The difference in velar width, pharyngeal depth and need's ratio among different age groups was statistically highly significant. Where as the difference in velar length among different age groups was not statistically significant (Table 5).

## DISSCUSION

Cephalometric analysis is inexpensive method & provides good assessment of soft tissue elements & commonly used for evaluating velar & pharyngeal morphology.[10,11,12] In the median sagittal plane on a lateral cephalogram the nasopharyngeal morphometric measurements & configuration of adjacent structure can be defined in terms of their depth & height.[12] Velar morphology variety was first observed by You M et.al.[2] In the present study new variants which did not fit into either of the categories were noted in all age groups except 30-35 & 40-45 group from which bifid variety was also observed in study done by Kruthika S Guttal in 9 cases (4.5%).[10] Type 1 velar morphology was most prevalent in studies done by You M et.al., Verma et.al., Gupta et.al., Smruthi et.al.[2,7,8,9] In the present study type 2 was most frequent type noted in all age groups except in group 20-25 type 1 and 2 was equally common which is in accordance with findings of Subramaniam N et.al. who observed rattail type (40.4%) in highest proportion and least common distorted S shaped and butt shaped (5.8%).[13] In study done by Gupta et.al. leaf shape was most common (28.3%) followed by rattail (23.3%) and butt shape (20%), least common type was crook and handle shaped.[8] In our study least common type noted was type 5 in accordance with Subramaniam N et.al. and Smruthi et.al. findings except in age group 40-45 least common was type 4 &7 where as in group 30-35 type 5 & 7 was least common.[7,13] In present study most common type observed in males was type 1 (30%), least common was type 4 (0.8%) and among females most common was type 2 (51.7%), least common type 5 (0%). Rahul et.al. in his study observed type 2 most common (19.7%) and type 6 (6%) least common among males and type 1 (22.7%) most common and type 4 (1.3%) least common among females.[14] The importance of soft palate's growth in maintaining velopharyngeal closure &

other function have been described by many authors. Velar length importance in maintaining velopharyngeal closure & harmonious growth of nasopharyngeal structure has been stressed in study by Satoh k et.al.[15] Pepin et.al found that high risk for obstructive sleep apnea in awake patients was associated with "hooked" morphology of velum which was described as "S-shaped" in our study.[5] Angulation of 30º between distal part of uvula & longitudinal axis of velum is defined as hooking of the velum which results in sudden & major reduction in oropharyngeal dimensions hence increasing the upper airway resistance & trans pharyngeal pressure gradients resulting in a pharyngeal collapse.[5,9,16] In the present study a significant decrease with small variation in VL was noted with increase in age which was not in accordance with findings of Johston & Richardson & Taylor et.al.[9,12,17] Kollia's & Krogstad showed that increase in VL was equal among males & females but in our study, it was noted to be significantly higher in males than in females which is in accordance with findings of Gupta et.al., Rahul et.al., and Raja Reddy et.al.[8,11,14,18] Velopharyngeal closure helps in separation of nasal cavity from oral cavity during swallowing, speech & pronunciation. If this closure does not occur, VPI develops.[19] Nakamuza et.al reported that patients with persistent VPI had a shortest VL & greater PD resulting in a lower value of need's ratio (PD/VL).[20] According to Subtelny, risk of VPI increase when need's ratio becomes greater than 0.70 & lesser value cause nasality of speech. In the present study need's ratio was higher in females than males which was in accordance with study of Guttal et.al, Raja Reddy et.al. but contradictory to Subtelny, Hoopes et.al & Simpson & Colton.[6,10,18,21] In the present study the difference in need's ratio among different variety of velum was statistically significant being max. in type 3 (butt like) (0.93) as compared to other previous studies in which crooked shape or S shape accounted for max. need's ratio.[6] Hence our study indicates that butt like shaped soft palate has greater chance towards VPI. In the present study, need's ratio was greater than 0.70 in all age groups except 35-40 group therefore indicating that further investigation is required in this age group individuals for ruling out VPI.

## LIMITATIONS

Limited sample size so larger sample size should be included in future studies.

Lack of patient's clinical evaluation.

Lack of confirmation between patients snoring history & increase in need's ratio.

## FUTURE SCOPE

Longitudinal study can be performed on same individual at different age intervals.

Similar analysis can be performed on CBCT.

## CONCLUSION

The present study was highlighted to investigate the various morphological appearance of soft palate as discussed by You M et.al using lateral cephalogram. Additional morphological variants were also observed. Need's ratio was higher among females than males thus implicating that chances of VPI were more among females & increase with increase in age. Butt like (type 3) soft palate is more prone towards velopharyngeal insufficiency according to our study in our population.

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