

## Correlation of morphological variants of the soft palate and Need's ratio in normal individuals: A digital cephalometric study

Pradhuman Verma<sup>1</sup>, Kanika Gupta Verma<sup>2,\*</sup>, Kikkeri Lakshminarayana Kumaraswam<sup>3</sup>,  
Suman Basavaraju<sup>4</sup>, Suresh K. Sachdeva<sup>1</sup>, Suruchi Juneja<sup>2</sup>

<sup>1</sup>Department of Oral Medicine and Radiology, Surendera Dental College and Research Institute, Sriganaganagar, India

<sup>2</sup>Department of Pedodontics and Preventive Dentistry, Surendera Dental College and Research Institute, Sriganaganagar, India

<sup>3</sup>Department of Oral Pathology and Microbiology, Farooqia Dental College, Mysore, India

<sup>4</sup>Department of Periodontics, J.S.S Dental College, Mysore, India

### ABSTRACT

**Purpose:** The present study was aimed to investigate the variation of soft palate morphology in different age and gender groups. The correlations of radiographic velar length (VL), velar width (VW), pharyngeal depth (PD), and Need's ratio with soft palate variants were also studied in the North Indian subpopulation.

**Materials and Methods:** The study sample consisted of 300 subjects aged between 15 and 45 (mean: 31.32) years. The velar morphology on lateral cephalograms was examined and grouped into six types. The results obtained were subjected to a statistical analysis to find the correlation between variants of the soft palate with gender and different age groups.

**Results:** The most frequent type of soft palate was leaf shaped (48.7%), and the least common was crook shaped (3.0%) among both the genders and various age groups, showing a significant correlation. The mean VL, VW, and PD values were significantly higher in males and significantly correlated with the types of soft palate. A significant correlation was observed between the mean VL, VW, PD, and Need's ratio with various age groups, showing an inconsistent pattern with an increase in age. The types of soft palate, gender, and Need's ratio were also significantly correlated, with an overall higher mean value of the Need's ratio among female subjects and the S-shaped soft palate.

**Conclusion:** The knowledge of a varied spectrum of velar morphology and the variants of the soft palate help in a better understanding of the velopharyngeal closure and craniofacial anomalies. (*Imaging Sci Dent 2014; 44: 193-8*)

**KEY WORDS:** Radiography; Morphology; Soft Palate; Analysis

### Introduction

The soft palate is the posterior fibro-muscular part of the palate that is attached to the posterior edge of the hard palate.<sup>1</sup> It participates in velopharyngeal closure, which is related to the normal functions of sucking, swallowing, and pronunciation.<sup>2</sup> Soft palate dysfunctions are frequently

seen in cleft lip and palate patients, enlarged adenoids, obstructive sleep apnea, poorly retained maxillary denture and skeletal craniofacial malocclusion.<sup>1,2</sup> The palate is formed by the fusion of three components, namely two palatal processes and the primitive palate, which is formed by the frontonasal process. At a later stage, the mesoderm in the palate undergoes intramembranous ossification to form the hard palate. However, the ossification does not extend into the most posterior portion, which remains as the soft palate.<sup>3</sup> There have been studies on the dimensional analysis of the soft palate morphology and its surrounding structures, but little attention has been paid to the vari-

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\*Correspondence to : Dr. Kanika Gupta Verma

Department of Pedodontics and Preventive Dentistry, Surendera Dental College and Research Institute, H.H. Gardens, Power House Road, Sriganaganagar 335001, Rajasthan, India

Tel) 91-1872-220089, Fax) 91-154-2440102, E-mail) praddy\_verma@yahoo.co.in

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ed soft palate morphology and configuration. You<sup>1</sup> et al classified the soft palate into six morphological 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) by observing the image of the velum on lateral cephalograms.

Pepin et al<sup>4</sup> found that the “hooked or S-shaped” appearance of the soft palate in awake patients indicated a high risk of the obstructive sleep apnea syndrome. Previous reports elucidated that the relationship between velar length (VL) and pharyngeal depth (PD) can be used to assess the velopharyngeal function. The ratio of PD to VL (PD/VL) was termed Need's ratio. Subtelny first reported that the Need's ratio ranged from 0.6 to 0.7 in normal subjects, and if it was greater than 0.7, the condition demonstrated a risk of velopharyngeal incompetency (VPI).<sup>5</sup> Studies reported that this ratio was of prime importance in speech resonance and there was a significant correlation between craniofacial growth changes and changes in resonance during puberty that might be influenced by both dentofacial orthopedics and maxillary surgery.<sup>6,7</sup> Further, the variability of Need's ratio measurements might possibly be related to the variation in adenoidal health conditions at various ages.<sup>8</sup> Haapanen et al reported that 27% of cleft lip and palate patients who underwent maxillary advancement surgery showed a reduced velopharyngeal function; they explained this situation by the advancement of the posterior border of the hard palate as a result of maxillary advancement.<sup>9</sup>

The purpose of the present study was to investigate the variation of the soft palate on lateral cephalograms in different age and gender groups, and to find its correlation with the Need's ratio in the North Indian subpopulation. The radiographic velar length (VL), velar width (VW), and pharyngeal depth (PD) in different morphological velar types, age groups, and gender were also studied.

## Materials and Methods

Three hundred digital lateral cephalograms were randomly selected from daily outpatients visiting the department of oral medicine and radiology from January to March 2013, requiring this radiograph for a diagnostic purpose. Informed written consent was obtained from each subject, and ethical clearance was obtained from the hospital's Institutional Ethics Committee (FSDCRI/IEC/2013/009; dated: 10.08.2013).

**Inclusion criteria:** Lateral cephalograms of the patients

within the age range of 15-45 (mean: 31.32) years, having a normal speech function were included in the study. The 300 study subjects were equally divided into six age groups (n=50) (Group 1: 15-20 (mean: 18.32) years, Group 2: 20-25 (mean: 22.98) years, Group 3: 25-30 (mean: 29.30) years, Group 4: 30-35 (mean: 33.92) years, Group 5: 35-40 (mean: 39.06) years, and Group 6: 40-45 (mean: 44.35) years.

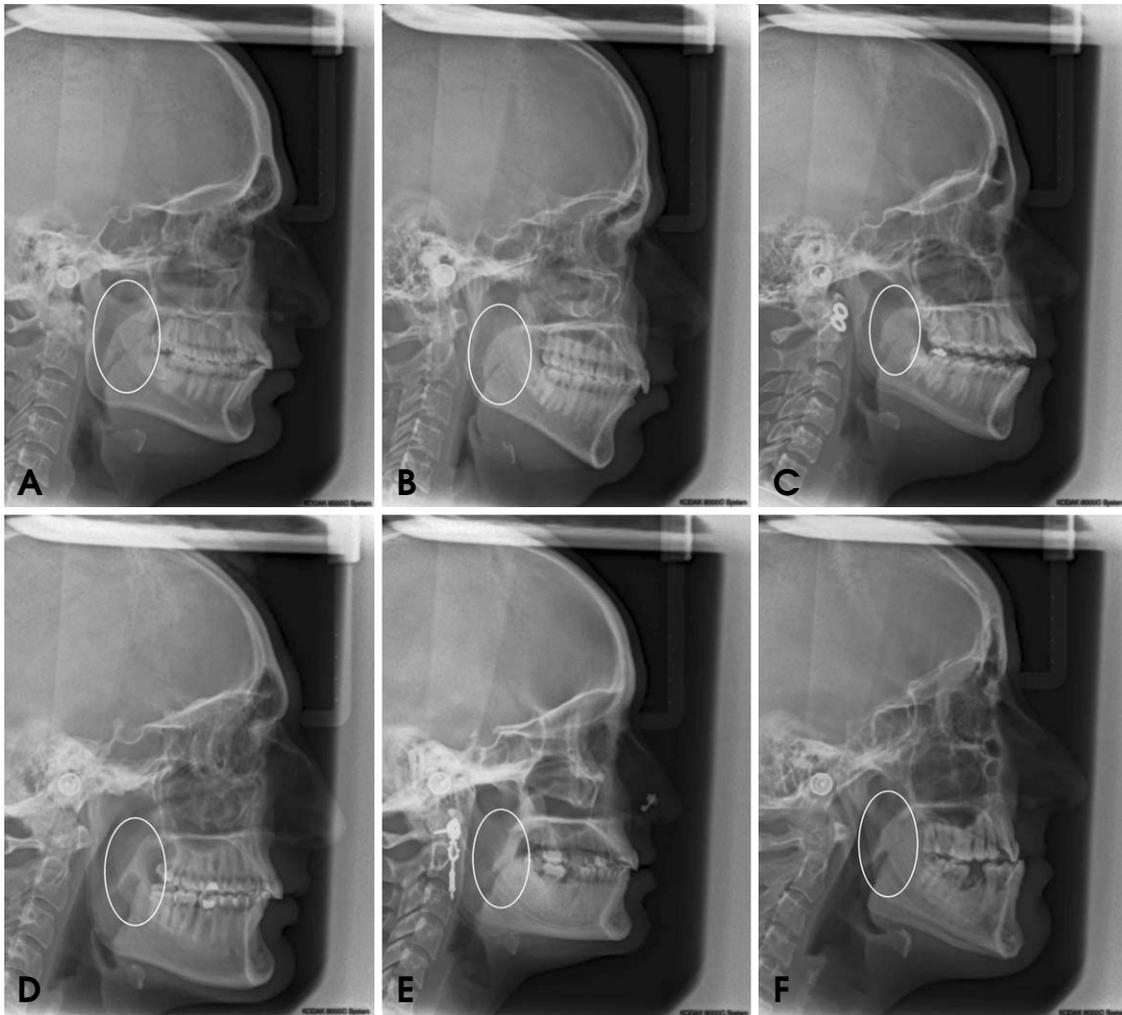
**Exclusion criteria:** Radiographs of patients with a history of cleft palate, systemic diseases, syndromes, or fracture of the head and neck were excluded from the study.

A lateral cephalometric analysis was performed to evaluate the velar and pharyngeal morphology as it is a relatively inexpensive method and provides a good assessment of the soft-tissue elements. All the lateral cephalograms were taken with the patients standing upright in a natural head position and were instructed to contact their molars and breathe through their nose (Fig. 1), so as to allow the same observation of the mobile sites of the soft palate and the upper airway, by one trained radiographer using the same digital radiographic machine (Kodak 8000C, Carestream Health Inc., Rochester, NY). A tube potential of 82 kV, a tube current of 10 mA, and an exposure time of 500 ms were used to optimize the contrast of the digital images. The digital radiographs were processed and viewed by using Kodak dental imaging software, version 6.12.24.0 (Carestream Health Inc., Rochester, NY, USA).

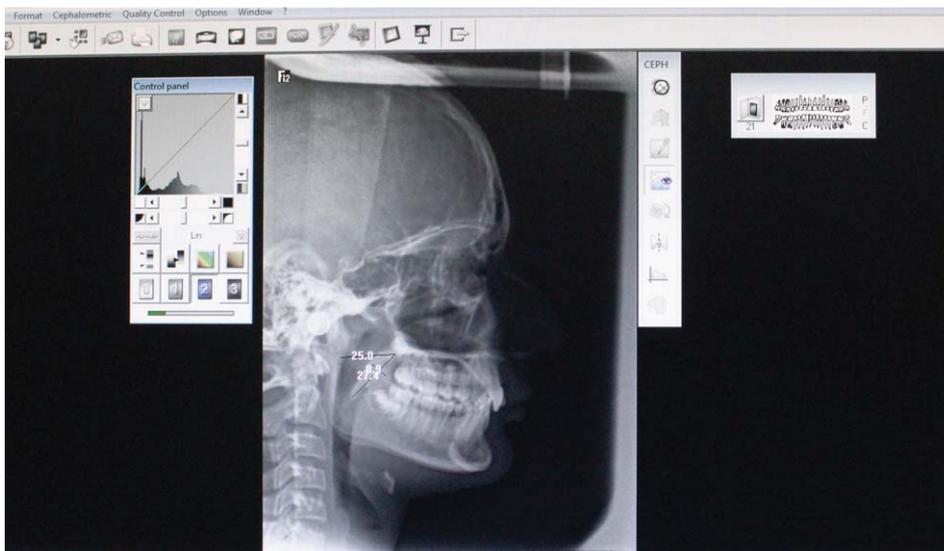
All the radiographs were analyzed and categorized into six types according to the soft palate morphology<sup>1</sup> by an oral and maxillofacial radiologist (Fig. 2). The VL was



**Fig. 1.** Lateral cephalograms are taken with a patient standing upright in the natural head position. The patient is instructed to contact his/her molars and breathe through his/her nose.



**Fig. 2.** Various velar morphologies are seen on lateral cephalograms. A. Type 1 “leaf-shaped” soft palate, B. Type 2 “rat-tail-shaped” soft palate, C. Type 3 “butt-like” soft palate, D. Type 4 “straight-line” soft palate, E. Type 5 “S-shaped” soft palate, and F. Type 6 “crook-shaped” soft palate.



**Fig. 3.** Measurements are taken on a digital lateral cephalogram using software.

**Table 1.** Distribution and correlation of types of soft palate with gender

Gender	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Total
Male	74	44	7	14	5	6	150
Female	72	49	5	12	9	3	150
Total	146	93	12	26	14	9	300
Percentage (%)	48.7	31.0	4.0	8.7	4.7	3.0	100.0
Pearson's correlation coefficient	1	0.993	0.967	0.994	0.885	0.878	1.000
p-value	–	0.074	0.164	0.069	0.308	0.318	0.015

**Table 2.** Correlation of types of soft palate with age groups

Age (years)	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Total
15-20	22	18	1	4	2	3	50
20-25	25	20	2	4	0	0	51
25-30	21	16	2	4	0	4	47
30-35	23	16	1	4	6	1	51
35-40	22	17	2	6	5	1	53
40-45	33	6	4	4	1	0	48
Total	146	93	12	26	14	9	300
Pearson's correlation coefficient	1	0.976	0.984	0.991	0.879	0.867	0.996
p-value	–	0.000	0.000	0.000	0.004	0.005	0.000

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

Variables	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	p-value
Velar length	31.28	31.68	30.09	30.97	30.21	31.35	0.000
Velar width	9.02	8.21	9.56	5.55	6.47	9.58	0.000
Pharyngeal depth	25.84	25.31	24.40	25.89	27.90	25.82	0.000
Need's ratio	0.78	0.75	0.76	0.80	0.86	0.76	0.000

evaluated by measuring the linear distance from the posterior nasal spine to the tip of the uvula of the resting soft palate. The VW measurement was taken at the thickest section of the velum. 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.<sup>10</sup> The measurements were carried out for each digital radiograph, saved in a JPG file format using Kodak software (Fig. 3), twice by the same examiner, and the obtained mean value was considered. The Need's ratio was calculated for all the subjects by the division of PD by VL, obtained at a resting position.

All the collected data were analyzed using the IBM SPSS Statistics 20.0 Data Editor software (Microsoft Corporation Inc., Chicago, IL, USA). A cross-tab was done by dividing the subjects into six age groups to compare with the types of soft palate, mean VL, VW, PD, and Need's ratio. The statistical correlation was also evaluated between morphological types and variants of the soft palate with both the genders. Pearson's correlation and *t*-test (2-

**Table 4.** Correlation of mean velar length, velar width, pharyngeal depth, and Need's ratio with gender

Variables	Male	Female	p-value
Velar length	31.69	29.96	0.018
Velar width	8.96	7.82	0.043
Pharyngeal depth	26.01	25.40	0.008
Need's ratio	0.75	0.80	0.021

tailed) were used to evaluate the relationship among variables in the cross-tabs.

### Results

The most frequent morphological velar type among 300 subjects was type 1 (48.7%), followed by type 2 (31.0%), type 4 (8.7%), type 5 (4.7%), and type 3 (4.0%), with the least common being type 6 (3.0%). A significant correlation ( $p < 0.05$ ) was observed between the types of soft palate and both the genders (Table 1). There was no case of type 6 velar noted in groups 2 and 6, while type 1 was

**Table 5.** Correlation of mean velar length, velar width, pharyngeal depth, and Need's ratio with age groups

Variables	15-20	20-25	25-30	30-35	35-40	40-45	p-value
Velar length	30.03	30.90	31.09	31.80	32.04	32.11	0.000
Velar width	8.12	7.90	8.55	8.29	8.58	8.92	0.000
Pharyngeal depth	25.83	25.45	24.93	25.72	26.14	26.16	0.000
Need's ratio	0.79	0.79	0.77	0.76	0.78	0.77	0.000

the most prevalent type in all the age groups. There was a highly significant correlation ( $p < 0.05$ ) noted among various velar morphological types and all the six age groups (Table 2).

The mean VL and PD were the shortest in type 3 and maximum in type 2 and type 4 soft palates, respectively. The mean VW was the shortest in type 4 and maximum in type 6, whereas the Need's ratio was noted to be the lowest in type 2 and the highest in type 5 velar morphology. The statistical analysis was done using a *t*-test (2-tailed), observing a highly significant correlation ( $p < 0.05$ ) between morphological types and variants of the soft palate (Table 3).

The mean VL, VW, and PD were greater in males, while the Need's ratio was larger among females. All the variants were significantly correlated ( $p < 0.05$ ) with both the genders (Table 4).

A consistent increase in VL was noted with an increase in age, while the VW, PD, and Need's ratio showed an inconsistent pattern. The statistical analysis was done using a *t*-test (2-tailed), observing a highly significant correlation ( $p < 0.05$ ) between various age groups and variants of the soft palate (Table 5).

## Discussion

Cephalometric analysis is the most commonly used technique for evaluating velar and pharyngeal morphology. It is a relatively inexpensive method and provides a good assessment of the soft-tissue elements that define the soft palate and its surrounding structures.<sup>11</sup> The nasopharyngeal morphometric measurements and configuration of adjacent structures can be defined in terms of their depth and height in the median sagittal plane on a lateral cephalogram. A digital radiographic technique is used as it enables the technician to take the image from the posterior to the anterior in the sagittal plane. Further, professional software is used to enhance and elicit the velar morphology by adjusting the contrast and for gradations.

In the present study, the type 1 (leaf shaped) soft palate was the most frequent type (48.7% cases), noted in our

study samples, which was in accordance with the previous studies of You et al,<sup>1</sup> Niu et al,<sup>12</sup> and Kumar and Gopal.<sup>3</sup> This type was previously described as classic velar morphology in the literature.<sup>13</sup> Type 6 velar morphology was seen in only 3.0% cases and was not found in groups 2 and 6.

Obstructive sleep apnea is characterized by the recurrent occlusion of the upper airways resulting due to the inspiratory collapse of pharyngeal walls during sleep.<sup>14,15</sup> Pepin et al<sup>4</sup> found that a "hooked" morphology of the velum, which was described as "S-shaped" in our study, indicated a high risk for obstructive sleep apnea in the awake patients. The hooking of the soft palate was defined as an angulation of 30° between the distal part of the uvula and the longitudinal axis of the velum. They hypothesized that soft palate hooking results in a sudden and major reduction in oropharyngeal dimensions, thus increasing the upper airway resistance and the transpharyngeal pressure gradient resulting in a pharyngeal collapse.<sup>16</sup> The type 5 (S-shaped) soft palate was seen in 4.7% of the cases in the present study, while it was observed in 3.5% of the cases in the study of You et al<sup>1</sup> and in 1.5% of the cases in Guttal et al's studies.<sup>13</sup>

In the present study, a significant increase in VL was noted with an increase in age. This was in accordance with the findings of Johnston and Richardson<sup>17</sup> and Taylor et al,<sup>11</sup> wherein the dimensional changes in the bony and soft tissues of oropharyngeal structures were assessed. Kollias and Krogstad<sup>18</sup> showed that the increase in the velar length was equal among males and females, but in our study, it was noted to be significantly greater in males than in females. The velar length in type 3 was significantly shorter than that in the other five types, which was accordance with You et al's study.<sup>10</sup> This might be due to the fact that with increasing age, VL increases and the velar features of some primary "butt-like" (type 3) soft palates might gradually present as the other types, such as types 1 and 2, which show a longer VL.

The velopharyngeal closure is obtained by a normal apposition of the soft palate with the posterior and lateral pharyngeal walls, thus separating the oral cavity from the

nasal cavity during deglutition and speech. When the velum, lateral, and posterior pharyngeal walls fail to separate the two cavities, VPI occurs.<sup>19</sup> Nakamura et al<sup>20</sup> reported that patients with persistent VPI had a shorter VL and greater PD, resulting in a lower value of the Need's ratio (PD/VL). The overall mean Need's ratio of 0.78 was reported in the present study, which was higher in females than in males. The results were in accordance with those of Guttal et al<sup>13</sup> but contradictory to the results of Subtelny,<sup>5</sup> Hoopes et al,<sup>21</sup> and Simpson and Colton.<sup>10</sup> According to Subtelny,<sup>5</sup> a Need's ratio greater than 0.70 demonstrates the risk of VPI, while a lesser value may cause nasality of speech. A highly significant correlation was found between the Need's ratio and six variants of velar types ( $p < 0.05$ ), which was similar to the results of Wada et al,<sup>22</sup> Praveen et al,<sup>16</sup> and You et al.<sup>1</sup> The mean VW, PD, and Need's ratio showed an inconsistent pattern with an increase in age in our study. This observation was in accordance with the findings of a study conducted by Guttal et al.<sup>13</sup>

Hence, the present study highlighted the variable radiographic appearances of the soft palate on lateral cephalograms with type 1 as a classic velar morphology. The statistical findings of pharyngeal morphology in this study might help in a better understanding of velopharyngeal closure and etiology of the obstructive sleep apnea syndrome. Further, the morphological variation of the soft palate plays an important anatomic role in functional rehabilitation of speech, breathing, and hearing; and managing patients with a cleft lip/palate, enlarged adenoids, obstructive sleep apnea, poorly retained maxillary denture, or skeletal craniofacial malocclusion.

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