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ORIGINAL RESEARCH

Morphological Varieties of Soft Palate in Normal Individuals, Cleft Palate Patients and Obstructive Sleep Apnea Patients with Reference to Indian Population: A Preliminary Digital Cephalometric Study

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ABSTRACT

Objective: To identify the morphological varieties of the soft palate on a digital lateral cephalogram in the median sagittal plane which is presented variously in normal individuals with age and gender and also to assess if there exists any morphological variations in the soft palate among cleft palate and obstructive sleep apnea (OSA) groups.

Materials and methods: A total of 120 normal subjects, 15 cleft palate patients and 15 OSA patients, whose ages ranged from 5 years and above were included. The morphology of the soft palate on lateral cephalometry was examined and classified into different types. The dimensional differences of the soft palate between the types and the differences in proportion to different age and gender groups were also studied in normal individuals, cleft palate patients and OSA patients.

Results: The morphology of the soft palate was classified into six types with an additional ungrouped type. There was a significant increase in the length of soft palate with age. In cleft palate patients, the predominant type of soft palate was type 3 with shorter velar length, while the predominant type of soft palate in OSA patients was type 1 with the length of the soft palate longer than that of the normal group. No significant difference was observed between males and females with respect to the mean length in normal group, cleft palate group and OSA group.

Conclusion: Soft palate presents variable radiographic appearances on lateral cephalometry. The classic velar morphology in cleft palate and OSA patients serves as an alternative modality of investigation to identify the etiology at an earlier stage.

Keywords: Soft palate, Cephalometric radiographs, Morphology, Cleft palate, Obstructive sleep apnea.

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INTRODUCTION

The cranium is a subtle complex structure with millions of distinctive appearances providing the primary interface for human interaction and communication. Soft palate is one such critical structure.

It is the fibromuscular part of the palate that is attached to the posterior edge of the hard palate. It participates in most oral functions, like velopharyngeal closure thus aids in sucking, swallowing and pronunciation.[1]

Constant efforts have been directed toward sophisticated analysis of the mechanisms of palate closure but, to date, few or no references have been made to the morphogenesis of the soft palate and its related structures. Considering the critical role that the soft palate plays in speech, this trend seems unusual.[2] Normal function of the soft palate is frequently not achieved even after soft tissue defect closure in cleft palates. The variation of the soft palate morphology may be a new explanation for surgical failure.[2,3]

Lateral cephalogram is an accepted technique for evaluating the various shapes of soft palate which presents itself in six different forms in normal individuals with variation of length in each type. It is also used in cleft palate patients since it permits a good assessment of soft tissue structures.[3,4]

Working and motor vehicle mishaps due to sleepiness have been anecdotally reported since 1929. Sleepiness has also been suggested as a major cause of the so-called mega-accidents of Chernobyl, Exxon Valdez and Bhopal. However, it is only within the last 10 years that the true dimension of the problem has been recognized. The estimated percentage of car accidents caused by sleepiness varies over a wide range from 0.4 to 30%.[5] The reason behind this could be sleep disordered breathing (SDB).

Obstructive sleep apnea (OSA) is one of the most common form of SDB, due to intermittent inspiratory closure of the pharyngeal airway during sleep resulting in episodic hypoxemia and sleep deprivation. The pathogenesis of OSA is complex and not fully understood yet, but a narrow and easily collapsible upper airway, may be due to many causes, such as aberrant cervicocraniofacial skeletal and soft tissue morphology.[6] By determining the site(S) of obstruction in patients with OSA followed by proper treatment, a reduction of accidents has been noted;[5] hence it is prudent to identify the etiology for this disorder.

MATERIALS AND METHODS

The study underwent review and approval by the ethical committee of the institution. Each patient was fully informed and explained about the lateral cephalometric procedure.

The study was conducted at the Department of Oral Medicine, Diagnosis and Radiology of Dayananda Sagar College of Dental Sciences, Bengaluru, and from Department of Sleep Medicine at SBM Jain Hospital, Bengaluru. A total of 150 patients were selected for the study by simple random sampling.

Subjects of age ranging from 5 years and above were included in the study. Fractures of head and neck, diseases affecting the palate, except cleft palate and OSA were included. Subjects were divided as group 1: Preadults (5-18 years) which were again categorized into subgroup 1A: 5-12 years and subgroup 1B: 12-18 years group 2: adults (above 18 years). Equal number of subjects were included in subgroups 1A, 1B and group 2 (40 in each) with equal number of females and males in each group. Group 3: 15 cases of cleft palate and group 4: 15 cases of OSA patients were included.

After an informed consent from the subjects, a detailed history of each patient was recorded along with clinical examination to rule out any cases with fracture of head and neck.

Questions were asked regarding cleft palate, surgical corrections they have undergone, number of surgeries and the reason for surgery and if the surgery has been successful.

Apnea risk evaluation system (ARES) questionnaire[7] was given to all the patients. Patients with BMI lesser than 31.5, neck size lesser than 43.2 cm (17.0 inches) for males or 39.4 cm (15.5 inches) for females with Epworth scale less than 10 were considered as normal individuals.

Diagnosed cases of cleft palate, those surgically corrected and also untreated cases were included in the study under group 3. Patients with documented history of OSA through overnight polysomnography were included as study subjects under group 4.

Digital lateral cephalograms were taken using orthopantomographic machine Ortho Phos. The tube potential was adjusted to optimize the contrast of both hard and soft tissues 84 kV, 13 mA for 9.4 seconds. A lateral cephalogram was taken with the tongue placed over the palate and slowly exhaling a deep breath. A cephalostat was used to keep the subject's head in a position such that the Frankfort horizontal line was parallel to the floor during exposure with the patient in standing position.

All of the images were then evaluated by two senior oral radiologists and the soft palate morphology was recorded. The length of the soft palate was evaluated by measuring the linear distance from the posterior nasal spine (PNS) to the tip of the uvula (Fig. 1). The measurement was carried out twice by the same examiner with the use of Master view software. The results were tabulated and analyzed using ANOVA test and the p-value test.

RESULTS

The soft palate was then classified into different types on the basis of the various radiographic appearances (Figs 2 to 8A to C). No significant differences were observed between the two set of observations in each group ($p > 0.05$) on comparison of shapes recorded by observer 1 and between observer 2.

Out of 120 normal patients, 46 had type 1 soft palate (38 %) followed by type 2, type 3, type 4, type 5, type 6 and type 7 (not grouped 2%) (Table 1).

A significant variation in the length of soft palate between different types was noted (Tables 2 and 3).

No significant variation in the type of soft palate between different age groups was noted on chi-square analysis (Table 1).

On comparison of velar length in millimeters in normal subjects, subgroup 1 and subgroup 2 had type 4 as the maximum length and type 2 had maximum length in adults (Tables 3 to 6).

The difference in mean length of the palate between the three age groups was found to be statistically significant ($p < 0.001$). Further, pairwise comparisons were carried out using Bonferroni test (Tables 4 to 6).

Type 1 was more common in both males and females. On chi-square test, no significant association exists between velar type and gender (Table 7).

The velar length of soft palate significantly increased with increase in age (Table 8). There was no significant difference observed with respect to the mean length between males and females (Table 9).

In cleft palate patients, the predominant type of soft palate was type 3 (Table 10). No significant difference was observed between males and females with respect to the mean length of soft palate (Table 9).

In OSA patients, the predominant type of soft palate was type 1 which was longer than the normal group (Table 11). No significant difference existed between males and females with respect to the mean length (Table 9).

DISCUSSION

The classification of soft palate based on its radiographic appearance as given by You et al[3] was considered in the study which included all the commonly found types of soft palate. Type 1 soft palate being present in 46 cases (38%)

MORPHOLOGICAL VARIETIES OF SOFT PALATE

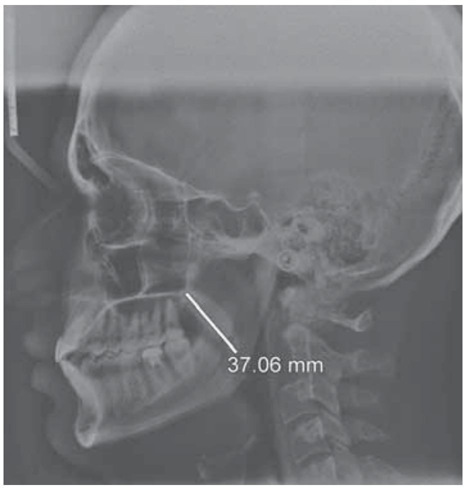


Fig. 1: Length of soft palate measurement from PNS to tip of uvula

Fig. 2: Type 1—lanceolate

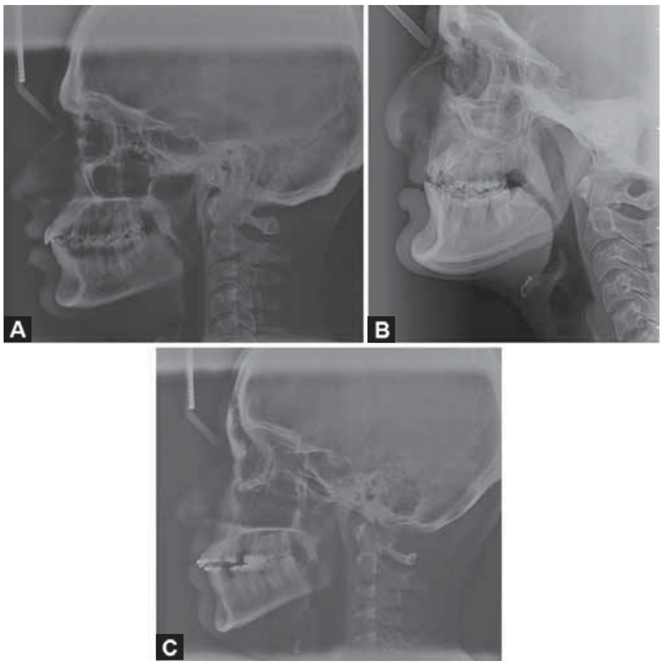
Fig. 3: Type 2—rat tail

Fig. 4: Type 3—butt type

Fig. 5: Type 4—rat tail

Fig. 6: Type 5—S-shape

Fig. 7: Type 6—crook



Figs 8A to C: Type 7—ungrouped type

and it was the most frequent type as observed by You et al,[3] Saraswathi et al[8] and Guttal et al.[9] This type was previously described as a classic velar morphology in the literature and is considered to be the most frequent type of presentation.

The type 7 or an ungrouped type of soft palate was found in our study which could not fit into any of the six types of soft palate, may be categorized under U-shaped soft palate which may possibly be a variant of the rat tail shape, with blunt end and (type 8) bifid-shaped soft palate as categorized by Guttal et al[9] in their study (Fig. 8).

The crook shape of soft palate was seen in eight individuals (7%) and found in the adult group in contrast to the You et al[3] study, where three (1.5%) cases were seen only in preadult group. This could be due to the small sample size in their study.

Table 1: Cross tabulation of age group and velar type in normal individuals ($p > 0.05$). There is no significant variation in the type of soft palate between different age groups

Shape	*5-12 years*		*13-18 years*		*>18 years*		*Total*	χ^2	*p-value*
	n = 40	%	n = 40	%	n = 40	%			
Lanceolate	10	25	21	53	15	38	46	20.382	0.060
Rat tail	15	38	5	13	8	20	28		
Butt	8	20	3	8	2	5	13		
Straight line	2	5	5	13	4	10	11		
Distorted S	4	10	4	10	4	10	12		
Crook shaped	1	3	2	5	5	13	8		
Not grouped	0	0	0	0	2	5	2		
Total	40	100	40	100	40	100	120		

Table 2: Comparison of velar length in millimeters in normal group between different types of soft palate

Shape	*n = 120*	*Mean*	*Standard deviation*	*SE of mean*	*95% CI for mean*		*Minimum*	*Maximum*	*p-value*
					Lower bound	*Upper bound*			
Lanceolate	46	33.96	4.21	0.62	32.71	35.21	26.12	46.49	<0.001*
Rat tail	28	33.50	4.50	0.87	31.72	35.28	20.05	42.28	
Butt	13	26.63	3.08	0.86	24.77	28.50	21.78	32.40	
Straight line	11	36.22	3.26	0.98	34.03	38.42	30.14	43.16	
Distorted S	12	30.42	2.83	0.82	28.62	32.22	27.09	35.63	
Crook shaped	8	33.15	3.44	1.22	30.27	36.03	25.89	37.49	
Not grouped	2	29.92	3.59	2.54	–2.35	62.19	27.38	32.46	

*$p < 0.05$. There is a significant variation in the length of soft palate between different types

Table 3: Comparison of velar length in millimeters in normal group

Shape	*5-12 years*		*13-18 years*		*>18 years*	
	Mean	*Standard deviation*	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*
Lanceolate	31.26	3.77	33.41	4.05	36.16	3.65
Rat tail	30.75	4.33	36.21	1.24	36.69	2.99
Butt	25.54	3.00	29.18	3.14	27.20	1.34
Straight line	32.52	3.36	37.53	3.34	36.45	2.19
Distorted S	31.77	4.17	29.31	1.74	30.19	2.19
Crook shaped	25.89	—	33.45	2.28	34.49	2.00
Not grouped	—	—	—	—	29.92	3.59

Table 4: Comparison of length between the three age groups in normal individuals

Age group (years)	*Mean*	*Standard deviation*	*SE of mean*	*95% CI for mean*		*Minimum*	*Maximum*
				Lower bound	*Upper bound*		
5-12	29.81	4.27	0.67	28.46	31.15	20.05	39.14
13-18	33.36	4.45	0.69	31.96	34.76	21.09	43.16
>18	34.79	6.33	0.77	33.26	36.32	13.64	49.40

Table 5: The difference in mean length of the palate between the three age groups was found to be statistically significant (p < 0.001). Further, pairwise comparisons are carried out using Bonferroni test

Age group (I) (years)	*Age group (J) (years)*	*Mean difference (I-J)*	*Standard error*	*p-value*	*95% CI for mean difference*	
					Lower bound	*Upper bound*
5-12	13-18	–3.554	1.181	0.009*	–6.415	–0.693
	>18	–4.984	1.058	<0.001*	–7.546	–2.423
13-18	5-12	3.554	1.181	0.009*	0.693	6.415
	>18	–1.430	1.058	0.535	–3.991	1.131
>18	5-12	4.984	1.058	<0.001*	2.423	7.546
	13-18	1.430	1.058	0.535	–1.131	3.991

*Denotes significant difference

The S-shape, which was described as a hooked appearance of the soft palate by Pepin et al,[4] was found in 12 (10%) cases of the normal individuals in our study, similar findings were also seen in other studies.[3,9] Hooking of the soft palate was defined in Pepin et al[4] study as an angulation of about 30° between the distal part of the uvula and the longitudinal axis of the soft palate. They hypothesized that soft palate hooking plays a key role in pharyngeal collapse, since hooking results in a sudden and major reduction in the oropharyngeal dimensions, which therefore dramatically increases upper airway resistance and the transpharyngeal pressure gradient. Pepin et al[4] therefore concluded that hooking of the soft palate in awake patients indicates a high risk for OSA syndrome.

In the present study, it was observed that a significant variation in the length of soft palate existed in different types similar to other studies[8,9] (Tables 4 to 6). Changes in the soft palate have been studied longitudinally in children and adults. An increase in the length of the soft palate has been found in all time periods.[10-12] It is therefore not surprising to find that the cases with type 3 velum in the subgroup 1 (5-12 years) of preadults were far greater than in the adult group, with a significantly shorter velar length than that in the other five types. The shortness of the velum in these patients did not affect the velopharyngeal functions of these subjects since a harmony exists between velar length and pharyngeal depth which contributes to normal velopharyngeal functions.

Subtelny et al[13] studied the growth of the soft palate and revealed that the average growth in length of the soft palate was found to be most rapid during the early years of life. After between approximately 1.5 to 2 years of age, the mean growth curve was observed to level-off or plateau and to

Table 6: Comparison of length between the three age groups

Age group	Mean	Std. dev.	SE of mean	95% CI for mean		Min.	Max.
				Lower bound	Upper bound		
5-12 yrs	29.81	4.27	0.67	28.46	31.15	20.05	39.14
13-18 yrs	33.36	4.45	0.69	31.96	34.76	21.09	43.16
>18 yrs	34.79	6.33	0.77	33.26	36.32	13.64	49.40
ANOVA:							
Source of variation	df	Sum of squares (SS)	Mean SS	F	p-value		
Between groups	2	641.295	320.647	11.20504	<0.001*		

*denotes significant difference. As the age increases the length of the soft palate is increasing in case of normal individuals

Table 7: Variation of soft palate shape among males and females between three age groups (p > 0.05). No significant association exists between velar type among different age groups and gender

Gender	Shape	5-12 years		13-18 years		>18 years		Total	χ^2	p-value
		n = 20	%	n = 20	%	n = 20	%			
Male	Lanceolate	4	20	11	55	11	55	26		
	Rat tail	5	25	3	15	3	15	11		
	Butt	6	30	2	10	1	5	9		
	Straight line	1	5	3	15	3	15	7	15.849	0.104
	Distorted S	4	20	1	5	1	5	6		
	Not grouped	0	0	0	0	1	5	1		
	Total	20	100	20	100	20	100	60		
Female	Lanceolate	6	30	10	50	4	20	20	12.334	0.419
	Rat tail	10	50	2	10	5	25	17		
	Butt	2	10	1	5	1	5	4		
	Straight line	1	5	2	10	1	5	4		
	Distorted S	0	0	3	15	3	15	6		
	Crook shaped	1	5	2	10	5	25	8		
	Not grouped	0	0	0	0	1	5	1		
	Total	20	100	20	100	20	100	60		

resume its upward trend after 4 to 5 years of life. Since there is no obviously rapid growth period after 5 years of age, there is no standard way to group them into different developmental stages.

In the present study, it was noted that there is a significant increase in velar length with increase in age (Table 6). This is in correlation with the findings of Taylor et al[11] wherein the dimensional changes in bony and soft tissues of oropharyngeal structures were assessed. It was observed in their study that there was 1 mm increase in length of soft palate and 0.5 mm increase in thickness of soft palate every 3 years after the age of 9 years. Similar observations were made by Johnston et al[16] wherein nasopharyngeal skeletal dimensions remained unchanged but the depth of airway in oropharyngeal region decreased and the soft palate became longer and thicker with the advancement of age. This finding is also similar to Guttal et al[9] in their study.

No significant association was seen between velar type and gender (Table 7). This is in similarity to the study by Praveen et al[17] and Kollias et al[12] in which dimensional changes between male and female young adults were compared. From their study, they inferred that increase in length, thickness and sagittal area of soft palate was equal among males and females.

Cleft palate has been morphometrically studied using lateral cephalograms both preoperatively and postoperatively.[14] A short soft palate is absolutely one of the important etiologies of velopharyngeal incompetence (VPI).

Type 3 soft palate with shorter velar length seen in cleft palate group clearly indicates that reduced velar length in these patients has led to VPI; this is in correlation with

Table 8: Morphological variation in length of soft palate with gender

Gender	*Shape*	*5-12 years*		*13-18 years*		*>18 years*	
		Mean	*Standard deviation*	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*
Male	Lanceolate	33.15	3.12	35.13	3.76	37.02	3.84
	Rat tail	30.79	1.43	35.91	1.56	36.80	2.29
	Butt	24.81	3.04	30.70	2.40	28.14	—
	Straight line	30.14	—	38.63	4.10	35.98	2.42
	Distorted S	31.77	4.17	28.91	—	33.26	—
	Not grouped	—	—	—	—	32.46	—
Female	Lanceolate	30.00	3.86	31.03	3.29	34.58	2.92
	Rat tail	30.72	5.78	36.51	1.06	36.61	3.79
	Butt	27.73	1.98	26.13	—	26.25	—
	Straight line	34.89	—	35.88	1.36	37.86	—
	Distorted S	—	—	29.44	2.11	29.16	0.94
	Crook shape	25.89	—	33.45	2.28	34.49	2.00
	Not grouped	—	—	—	—	27.38	—

Table 9: Comparison of length between the three groups

Group	*Mean*	*Standard deviation*	*SE of mean*	*95% CI for mean*		*Minimum*	*Maximum*
				Lower bound	*Upper bound*		
Normal	32.78	4.61	0.42	31.95	33.62	20.05	46.49
Cleft palate	28.44	7.03	1.76	24.70	32.19	13.64	38.34
Obstructive sleep apnea	39.93	6.18	1.60	36.51	43.36	29.52	49.40

Table 10: Comparison between males and females: (t-test). No significant difference is observed between males and females with respect to the mean length in any of the groups ($p > 0.05$)

Group	*Gender*	*Mean*	*Standard deviation*	*SE of mean*	*Mean difference*	*t*	*p-value*
Normal	Male	33.49	4.82	0.62	1.457	1.736	0.085
	Female	32.04	4.30	0.56			
Cleft palate	Male	28.30	8.11	2.34	−0.581	−0.138	0.892
	Female	28.88	2.42	1.21			
Obstructive sleep apnea	Male	41.03	5.80	1.61	8.227	1.912	0.078
	Female	32.81	3.74	2.65			

a study by Subtelny et al[13] which reported that the need ratio, which is established between the length of velum and pharyngeal depth (pharyngeal depth/velar length), was from 0.6 to 0.7 in normal subjects. It was also suggested that a need ratio greater than 0.7 demonstrated a risk for VPI. Lesser the velar length greater is the need ratio and thus leading to VPI.

All the patients in the OSA group in the study belonged to the adult group suggesting a high prevalence of this disease in middle aged adults. The correlation between age and OSA has been studied by various researchers, yielding disparate results with the suggestion of rise in the prevalence of OSA with age. Ip et al[15] found that prevalence of OSA tends to rise in the older population. It was found that pharyngeal morphology is not immutably established during childhood and adolescence, but changes throughout adult life. There is a tendency toward longer and thicker soft palate and narrower oropharynx during adulthood.[16] This may explain the possible increased incidence of OSA and related disorders occurring later in life.

Table 11: Distribution and proportion of soft palate morphology types in cleft palate patient

Group	*Cleft palate*	
	n = 15	*%*
Lanceolate	2	13.33
Rat tail	3	20
Butt	9	60
Straight line	0	0
Distorted S	0	0
Crook shaped	0	0
Not grouped	1	6.67
Total	15	100

Table 12: Descriptive shape of soft palate in OSA patients

Group	*Obstructive sleep apnea*	
	n = 15	*%*
Lanceolate	6	40
Rat tail	4	26.67
Butt	1	6.67
Straight line	2	13.33
Distorted S	2	13.33
Crook shaped	0	0
Not grouped	0	0
Total	15	100

Pepin et al[4] had concluded that hooking of the soft palate seen on a lateral cephalograms in awake patients indicates a high risk for OSAS but in our study 'S'-shaped soft palate was seen in only two patients among the 15 OSA patients taken in the study (Table 12). It can be supposed that the number of subjects in the investigation was not large enough or there are many other etiologies for OSA (aberrant cervicofacial skeletal and soft tissue morphology, atypical tongue muscle activity, fat deposition around neck and pharynx, mandibular deficiency, low hyoid bone position and narrow posterior airway space) which were not ruled out while selecting the patients and lateral cephalometry being a two-dimensional view like all other conventional radiographs falls short of the third dimension.

A significant increase in the length of soft palate in the 15 OSA patient group compared to normal individuals was also noted in the present study (Table 9) which is similar to other cephalometric studies on OSA where the length of the soft palate was considered to be longer.[4,18-24] Thus, the findings in the study certainly put forth the competence of lateral cephalometry in evaluating the morphology of soft palate in patients with OSA.

Scope for positive early prediction of OSA through the use of lateral cephalometric analysis of upper airway and craniofacial structures does exist and requires a more extensive research on similar lines with a larger sample size.

Longitudinal studies, with more subjects, and comparisons with more cleft palate patients should be carried out to better understand the morphology of soft palate in these patients and assess long-term treatment results. Pre- and postoperative study has to be conducted on the same cleft palate patient in further studies which would enable the study of variations in the shape of soft palate among pre and postoperative cases.

A more extensive study on similar lines with larger sample size in OSA group with the exclusion of all other etiological factors other than soft palate should be done by careful selection of samples which would help in establishing lateral cephalometry as an efficient predictive, diagnostic as well as treatment planning tool in treatment of OSA.

CONCLUSION

The morphology of the soft palate can be divided into different types according to their features on lateral cephalometry. Significant difference is seen in the length of soft palate with age while no definite association exists between velar type and gender. The classic velar morphology in cleft palate serves as an alternative modality of investigation to assess the cleft palate patients pre- and postoperatively. It is hoped that by characterizing the morphological type of the soft palate we may be able to identify a potential disorder, such as OSAS, at an early stage using lateral cephalograms.

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