

## Comparative morphometric analysis of soft palate between OSMF and normal individuals: A digital cephalometric study

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### Abstract

**Aim:** To investigate morphometric variation of the soft palate on lateral cephalogram in different stages of Oral submucous fibrosis.

**Objectives:** To evaluate the radiographic velum length, velum width, angle/inclination of velum and pharyngeal depth divided by velum length giving Need's ratio in different morphological types of soft palate and different stages of OSMF and to determine correlation of all metric parameters with respect to staging of OSMF. Also, correlation of staging of OSMF with respect to different types of soft palate was evaluated.

**Materials & Method:** Lateral cephalographs of 80 cases with age range 18-45 years irrespective of gender were evaluated. Soft palatal patterns were categorized based on You et al. et al's classification & staging of OSMF was done according to Kiran Kumar et al's classification. Total 80 cases were divided into two groups such as Group A (OSMF = 40) and Group B (Control = 40) Group A (40 OSMF) and Group B (40 Control). The length, width, angle of inclination and need's ratio was evaluated in each type of soft palate. Mann-Whitney test and Kruskal Wallis test was used for statistical analysis.

**Results:** The mean age of the 80 cases was 40.5 years. The highest incidence of soft palate seen in group A and B was type 1, whereas the lowest incidence was type 5 in Group A and type 6 in Group B. The mean and Standard deviation of length, width, angle of inclination and need's ratio in group A was  $22.43 + 0.76$ ,  $23.91 + 0.94$ ,  $127.72^\circ + 1.21$  and  $0.8 + 0.57$  respectively and that of control group was  $24.47 + 1.10$ ,  $21.60 + 0.58$ ,  $131.6^\circ + 0.75$  and  $0.63 + 0.97$  respectively. Stage 1 OSMF subjects had maximum type 2 soft palate (4%), Stage 2 had type 1 (45%) and stage 3 had type 6 (5%).

**Conclusion:** With OSMF staging advancement, length and angle of inclination of soft palate shows negative, whereas width and the need's ratio shows positive correlation.

**Keywords:** Obstructive sleep apnea, Oral submucous fibrosis, Soft palate

### Introduction

Oral submucous fibrosis (OSMF) is one of the most common premalignant conditions affecting the oral cavity of people consuming areca nut and gutka.<sup>(1)</sup> It is a chronic, progressive, scarring disease that predominantly affects the people of South-East Asian origin, including the Indian subcontinent.<sup>(2)</sup> OSMF is characterized by juxta epithelial inflammatory reaction and progressive fibrosis of the submucosal tissues that affects most parts of the oral cavity, including soft palate (also known as velum or muscular palate), pharynx and upper third of the oesophagus.<sup>(3)</sup> According to the literature, as the OSMF progresses the morphology of the soft palate changes.<sup>(2)</sup>

The soft palate is the posterior fibrovascular part of the palate that is attached to the posterior edge of the hard palate.<sup>(4)</sup> It participates in most of the oral functions like speech, swallowing, and respiration.<sup>(5)</sup> Soft palate plays a very crucial role in velopharyngeal closure, that is, approximation of soft palate with pharyngeal walls. This sphincter mechanism separates nasal and oral cavity during speech and deglutition.<sup>(6)</sup>

The relationship between velum length (LV) and pharyngeal depth (PD) can be used to assess the velopharyngeal function.<sup>(7)</sup> The ratio of [PD] to [LV] (PD/VL) is termed as Need's ratio (NR). Subtelny first reported that the NR 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>(7)</sup> Studies reported that this ratio was of prime importance in speech resonance. It was found that, there was a significant correlation between craniofacial growth and associated changes in resonance during puberty, which might be influenced by both dentofacial orthopedics and maxillary surgery.<sup>(8,9)</sup>

Velopharyngeal insufficiency and hyper nasal speech are still the topic of debate in surgically successful but functionally compromised cases of pharyngeal flap,<sup>(6)</sup> owing to varied morphologies of soft palate and surrounding structures. Henceforth, proper assessment of soft tissue morphology is mandatory to gain better results.

Till date, there have been few studies done on OSMF patients for assessing dimensional changes in soft palate using digital cephalogram in which length and width were used as radiographic markers.<sup>(10,11,12,13,14)</sup> As per our knowledge, this is first attempt, in the present study, to use (AV) and (NR) of soft palate as radiographic marker/landmark for assessment of dimensional changes in soft palate.

Purpose/Aim of the present study was to investigate morphometric variation of the soft palate on lateral cephalogram in different stages of OSMF. The objective was to evaluate the radiographic velum length

(LV) velum width (WV), angle/inclination of velum (AV) and need's ratio (NR) in different morphological types of soft palate and different stages of OSMF determine correlation of all metric parameters with respect to staging of OSMF. Also, correlation of staging of OSMF with respect to different types of soft palate was evaluated.

### Materials and Method

The study was conducted in Oral medicine and radiology department in MGVS Dental college and Hospital, Nasik, India. Protocol of the study was approved from authorized ethical committee. Also, written informed consent was obtained from each subject prior to the study.

The Digital lateral cephalographs were taken using CBCT dental imaging system (SIRONA, Germany) operating at 60 kVp and 3mA and FOV used was 8 × 8 cm with 14 second of exposure time. Total 80 subject's scan of age range 18- 45 years irrespective of gender were selected randomly.

Clinically and histopathologically diagnosed subject's of OSMF with no history of treatment for OSMF and free of any other systemic diseases or syndromes were included in the study. The OSMF subjects were classified as per the classification given by Kiran Kumar et al (2007) into three clinical stages of OSMF on the basis of mouth opening as follows:

Stage I: Mouth opening >45 mm

Stage II: Restricted mouth opening 20 to 44 mm

Stage III: Mouth opening <20 mm.

The subjects of OSMF were classified, as the morphology of soft palate changes as the staging of OSMF advances. Subject's suffering from scleroderma or with any history of surgery in the region of hard and soft palate and the undergoing any radiation therapy or with any such history were excluded.

All 80 subjects soft palate were morphologically classified according to You et al. all classification into 6 types.(Fig. 1)

1. Type 1: "Leaf-shape," which was lanceolate, indicating that the middle portion of the soft palate elevated to both the naso-and the oro-side.(Fig. 1a)
2. Type 2: "rat-tail shape." When the soft palate showed that the anterior portion was inflated and the free margin had an obvious coarctation.(Fig. 1b)
3. Type 3: "butt-like", soft palate showed a shorter and fatter velum appearance, and the width had almost no distinct difference from the anterior portion to the free margin.(Fig. 1c)
4. Type 4: "straight line shape." Which indicated that the image of the soft palate presented a "straight line shape.(Fig. 1d)
5. Type 5: S-shape, the distorted soft palate presented the S-shape.(Fig. 1e).
6. Type 6: "crook" appearance, which revealed a "crook" appearance of the soft palate, in which the

posterior portion of the soft palate crooks anterosuperiorly.(Fig. 1f)

Total sample of 80 subjects was divided into two groups [40 subjects per group]

Group A: OSMF Group

Group B: Control Group. (These were the subject's who required lateral cephalograms for some other diagnostic purpose.)

Following parameters were noted on digital lateral cephalograph.

1. Length of velum [LV]: as linear distance measurement from posterior nasal spine to the tip of uvula of resting soft palate,
2. Width of velum [WV]: as linear measurement at thickest portion of soft palate and perpendicular to its length,
3. Pharyngeal depth [PD]: as linear measurement from the posterior surface of the nasal spine marker to the posterior pharyngeal wall along the palatal plane,
4. The Need's ratio[NR] [was calculated for all the subjects by the division of PD by LV, PD/LV obtained at a resting position,
5. Angle of velum [AV]: as angle formed between line joining (anterior nasal spine –posterior nasal spine) and line (posterior nasal spine to tip of uvula ).(Fig. 2)

Distribution of types of soft palate in both the groups (A& B), Comparison of length, width, angle of inclination and need's ratio in the OSMF and control group using Kruskal Wallistest, Mean distribution of length, width, angle of inclination and need's ratio in the OSMF group and control group using Mann Whitney U test, cross tabulation for type of soft palate and staging of OSMF and: The mean length, width, angle of inclination and need's ratio of soft palate patterns according to stage wise distribution of OSMF using Kruskal Wallis test was evaluated. *p*value< 0.05 was set to be statistically significant.

### Results

The digital lateral cephalographs of total 80 cases [Group A = 40 and Group B= 40] were evaluated. The mean age of the subjects was 40.5 years.

All the soft palates were classified into six types of soft palate given by You et al. all (2008). As per the above classification, in the present study, type 4 soft palate could not be appreciated in both the groups and type 5 soft palate was seen in only one subject of group A. (Table 1). The highest incidence of soft palate seen in group A and B was type 1, whereas the lowest incidence was of type 5 in Group A and type 6 in Group B. This states that control group has less crooked shaped soft palate as compared to OSMF group.

**Table 1: Distribution of types of soft palate in group A & B in percentages**

Types of soft palate	Group A (OSMF Group)	Group B (Control Group)
Type 1	16%	36.25%
Type 2	11.25%	7.5%
Type 3	8.75%	3.75%
Type 5	1.25%	0%
Type 6	12.5%	2.5%

Kruskal Wallis test was used for comparing the mean values of length, width, angle of inclination and need's ratio in both groups according to type-wise distribution, showing significant difference ( $p < 0.05$ ) in LV, WV, AV and N.R in type 1. In type 2 and 3 soft palate patterns, a difference in dimensions was significant only with WV and N. R respectively. In type 6, difference in dimensions was insignificant with both WV and N.R. The highest length, width and angle of inclination was observed in crook shape soft palate and highest need's ratio was observed in crook shape soft palate in both groups (Table 2).

**Table 2: Comparison of length, width, angle of inclination and need's ratio in the OSMF and control group using Kruskal Wallis test**

Types of Soft palate	Parameters	Groups	Number [N]	Mean	Standard Deviation	P value
1	LV	A	13	22.40	0.37	<0.01**
		B	29	23.99	0.72	
	WV	A	13	24.05	0.35	<0.01**
		B	29	21.65	0.57	
	AV	A	13	127.5	0.98	<0.01**
		B	29	131.69	0.78	
N.R	A	13	0.7	0.48	<0.01**	
	B	29	0.5	0.58		
2	LV	A	9	22.82	0.708	<0.01**
		B	6	25.65	0.88	
	WV	A	9	22.6	1.002	0.09
		B	6	21.80	0.442	
	AV	A	9	128.7	1.12	<0.01**
		B	6	131.6	0.83	
N.R	A	9	0.8	0.03	<0.01**	
	B	6	0.73	0.51		
3	LV	A	7	22.21	1.15	<0.01**
		B	3	25.30	0.98	
	WV	A	7	24.31	0.453	<0.01**
		B	3	20.86	0.378	
	AV	A	7	127.5	0.50	<0.01**
		B	3	131.5	0.43	
N.R	A	7	0.82	0.48	0.07	
	B	3	0.73	0.057		
5	LV	A	1	23.30	-	<0.01**
		B	0	0	-	
	WV	A	1	24.2	-	-
		B	0	0	-	
	AV	A	1	128.9	-	-
		B	0	-	-	
N.R	A	1	0.8	-	-	
	B	0	-	-		
6	LV	A	10	22.19	0.80	<0.01**
		B	2	26.70	0.28	
	WV	A	10	24.59	0.486	0.12
		B	2	21.40	0.84	
	AV	A	10	127.08	1.44	<0.05*
		B	2	131.7	0.98	

	NR	A	10	0.82	0.78	0.67
		B	2	0.85	0.85	

[\*Units of measurement: Length, width in mm and angle of velum in degree]

Mann-Whitney *U* test was used to measure the length, width, angle of inclination and need's ratio of soft palate showing mean value of length as 22.43 in OSMF group and 24.47 in control group. Mean value of width was 23.91 and 21.96 in OSMF and control groups, respectively. Mean value of angle of inclination was 127.72° and 131.6° in OSMF and control groups, respectively. Mean value of need's ratio was 0.8 and 0.6 in OSMF and control groups, respectively, with statistically significant *p* value of 0.001. This indicates that length and angle of inclination was significantly greater in the control group, while width and need's ratio was significantly greater in the OSMF group. This specifies that the soft palate becomes short and stout/bulky in OSMF (Table 3).

**Table 3: Mean distribution of length, width, angle of inclination and need's ratio in the OSMF group and control group using Mann Whitney *U* test**

Parameters	Groups	Number (N)	Mean value	Standard deviation	p value
LV	A	40	22.43	0.76	< 0.01**
	B	40	24.47	1.10	
WV	A	40	23.91	0.9	< 0.01**
	B	40	21.6	0.58	
AV	A	40	127.72	1.21	< 0.01**
	B	40	131.66	0.75	
N.R	A	40	0.8	0.57	< 0.01**
	B	40	0.6	0.97	

Type-wise distribution of soft palate patterns according to staging of OSMF in the OSMF group showed 45% of subjects with type 1 and 13.7% of subjects with type 2 soft palate pattern in stage II OSMF. 10% of type 3 and the highest percentage of subjects 15% showing type 6 soft palate variant were seen in stage III OSMF. One in stage III showed type 5 & 6 variant. (Table 4)

Type 2	4 %	13.7 %	0 %
Type 3	0 %	2.5 %	10 %
Type 5	0 %	0 %	1.25 %
Type 6	0 %	0 %	15 %

**Table 4: Cross tabulation for type of soft palate and staging of OSMF**

Types of soft palate	Stage 1	Stage 2	Stage 3
Type 1	2.5 %	45 %	5%

The mean length, width, angle of inclination and need's ratio of soft palate patterns according to stage wise distribution of OSMF revealed that the length & angle of inclination of soft palate is significantly greater in stage I than in stage II. The width and need's ratio of stage III palate is significantly greater than of stage I and stage II (Table 5).

**Table 5: The mean length, width, angle of inclination and need's ratio of soft palate patterns according to stage wise distribution of OSMF using Kruskal Wallistest**

Parameter	Staging of OSMF	Number (N)	Mean value	Standard deviation	p value
LV	1	7	22.73	0.72	< 0.01**
	2	28	22.62	0.44	
	3	5	22.43	0.56	
WV	1	7	22.13	0.41	< 0.01**
	2	28	24.18	0.32	
	3	5	24.9	0.6	
AV	1	7	129.0	1.15	< 0.01**
	2	28	127.6	0.86	
	3	5	126.4	1.49	
N.R	1	7	0.8	0.37	< 0.01**
	2	28	0.7	0.47	
	3	5	0.9	0.0	

Interestingly, a negative correlation was observed in staging of OSMF and length and angle of inclination of soft palate. That is, as the staging increases, the length and angle of inclination dimension decreases, but the width and need's ratio increases along with staging.

## Discussion

OSMF is a chronic in Sidious disease of the oral cavity affecting mucosa and submucosa of soft palate, anterior faucial pillars, buccal mucosa, tongue, and lips.<sup>(3,15)</sup> Gaining meticulous knowledge regarding changes in soft palate morphology due to OSMF will be helpful for proper diagnosis of the progress of the disease in oropharyngeal region. It will also help for its successful structural & functional outcome. Clinical detection of structural narrowing of the upper airway may facilitate early recognition of obstructive sleep apnea.<sup>(16)</sup> 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.

OSA is characterized by the recurrent occlusion of the upper airways resulting due to the inspiratory collapse of pharyngeal walls during sleep.<sup>(17,18)</sup> Pepin et al in 1999<sup>(19)</sup> found that a "hooked" morphology of the velum, which was described as "S-shaped" in present study, indicated a high risk for obstructive sleep apnea (OSA) 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. Pepin et al. 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>(20)</sup> In the present study, only one patient of stage 3 of OSMF had type 5 soft palate. Thus, indicating its highest risk for OSA.

In the present study, Group A (OSMF group) showed predominantly type 1 (16% leaf shaped) soft palate. This was similar to the study conducted by Chintamaneni. L et al. in 2016.<sup>(14)</sup> The least common was type 5(S shaped 1.25%) and absence of type 4 (straight line shape 0%) soft palate. This was contrary to Chintamaneni. L et al. of 2016 study, which showed least common as type 4 and absence of type 5 soft palate. Whereas, in Group B (Control group) in the present study, Type 1 (leaf shaped 36.25%) was most predominantly seen and type 6 (crook shape 2.5%) was least common.(Table 1) This results were in accordance to the results of You et al. of 2008,<sup>(4)</sup> Kumar and Gopal of 2012,<sup>(21)</sup> and Verma et al. of 2014<sup>(12)</sup> study.

Findings of (Table 4) suggest, that the soft palate shows morphological changes with the progression of

the disease, that is, long narrow type getting transformed into short thick pattern. These changes were attributed to the fibrosis of the mucosal covering of soft palate and uvula. These findings were in accordance with Shankar et al.<sup>(11)</sup> & Mohan et al. of 2014<sup>(12)</sup> and Chintamaneni. L et al. of 2016.<sup>(14)</sup>

As per findings of type 1 (leaf shape) soft palate in (Table 2), there is significant reduction in length and increment in width of the soft palate in the OSMF group when compared with control group. The results with respect to only length was in accordance to the study results of Shankar et al.<sup>(11)</sup> The difference with respect to angle of inclination was statistically significant in all types of soft palate except type 4 and 5 (Table 4) and thus it can be concluded that there is marked decrease in angle of inclination of soft palate in OSMF group as compared to that of control group. Till now, as per our knowledge this is the first attempt to measure angle of inclination of soft palate in OSMF group and to compare with Control group. But, this was similar to the angle of inclination of normal individuals found to be in range of 129.03° to 131.36° in Kruthika et al. of 2013 study.<sup>(22)</sup> The need's ratio in OSMF group was 0.7 and in control group it was 0.6 in the present study. This was not similar with respect to Pradhuman V et al. of 2014 study, in which it was found to be 0.78 in type 1 of soft palate of normal individuals<sup>(23)</sup> but was similar with respect to subtenly et al. study, which stated range of 0.6-0.7 of needs ratio in normal individuals.<sup>(7)</sup> He also stated that needs ratio >0.7 states VPI. Thus, we can conclude that the needs ratio in the present study of type 1 palate indicates a mild to moderate risk of VPI. Till now, as per our knowledge this is the first attempt to measure needs ratio in OSMF group and to compare with Control group. This type of soft palate was seen in 2 cases of stage 1, 36 cases of stage 2 and 4 cases of stage 3 of OSMF.(Table 4)

There is significant reduction in length and increment in width of type 2 (rat-tail like shape) soft palate in the OSMF group when compared with control group.(Table 2) The results were contrary to the study results of Shankar et al.<sup>(11)</sup> The need's ratio in control group was 0.7 in the present study. This was similar with respect to Pradhuman V et al. study, in which it was found to be 0.72 in type 2 of soft palate of normal individuals.<sup>(23)</sup> Thus, type 2 palate indicates a mild to moderate risk of VPI. This type of soft palate was seen in 4casesof stage 1, 11 cases of stage 2 of OSMF.(Table 4)

There is significant reduction in length and increment in width of type 3(butt shape) soft palate in the OSMF group when compared with control group.(Table 2) The results with respect to length was in accordance to that of Shankar et al.<sup>(11)</sup> The need's ratio in control group was 0.6, which was not similar to Pradhuman V et al. study, in which it was found to be 0.76 in type 3 of soft palate of normal individuals.<sup>(23)</sup>

Thus, type 3 palate indicates a mild to moderate risk of VPI. This type of soft palate was seen in 2 cases of stage 2 and 8 cases in stage 3 of OSMF. (Table 4)

Type 4 (straight line) variety of soft palate was seen in one case in each of stage I and II OSMF of Chintamaneni. L et al.<sup>(14)</sup> Amusingly, this type of soft palate was not observed in our study.

No case was found with type 5 soft palate in control group. Kumar and Gopal<sup>(21)</sup> conducted a study in 100 normal individuals to evaluate the soft palate patterns and found only 2% of the cases showing S-shape (type 5) pattern of soft palate. Praveen et al.<sup>(20)</sup> reported 2.5% of the cases presented with this pattern. Pepin et al. found the S-shape (type 5) which had hooked appearance of the soft palate in their study, with angulation of about 30° between distal part of uvula and longitudinal axis of soft palate. Therefore, the study concluded that hooked appearance in awake patients indicates a high risk for obstructive sleep apnea syndrome.<sup>(19)</sup> The results with respect to only length of type 5 of present study was in accordance to the study results of Shankar et al.<sup>(11)</sup> The angle of inclination for OSMF group was 128.9°. The need's ratio in OSMF group was 0.8. Thus, we can conclude that type 5 palate indicates highest risk of VPI. This type of soft palate was seen in only 1 case of stage 3 of OSMF. (Table 4)

There is significant reduction in length and increment in width of the soft palate (Table 2) similar to Chintamaneni. L et al study<sup>(14)</sup> in the OSMF group when compared with control group. The needs ratio in the present study of type 6 palate indicates a mild risk of VPI. This type of soft palate was seen in 12 cases of stage 3 of OSMF. (Table 3)

In our study, there was a gradual change in the dimensions and patterns of soft palate with advance in staging of OSMF and interestingly a negative correlation was observed in staging of OSMF length and angle of inclination. That is, as the staging advances, the length and angle of inclination decreases, but the width increases along with staging. Type 1 and 2 variants of soft palate were predominantly seen in initial stages of OSMF, whereas type 3 and 6 variants were observed in advanced stages of OSMF.

Morphometric assessment of the nasopharynx or the configuration of adjacent structures can be defined in terms of depth and height in median sagittal plane on lateral cephalogram.<sup>(24)</sup>

So, the strength of this study was use of cephalographs. It is a relatively inexpensive method and permits good assessment of the soft tissue elements that defines the soft palate and its surrounding structure. The limitation of the study was unequal distribution of stages of OSMF subjects. There is further scope for validating this study with a larger sample size and equal distribution of stages of OSMF.

## Conclusion

We can conclude that as the staging of OSMF disease advances, the morphometric changes seen with respect to soft palate is gradual increase in its width, decrease in its length and angle of inclination. There is a negative correlation between angle of inclination and need's ratio. As a result as the need's ratio increases, the risk of VPI increases. VPI is also directly correlated with type of soft palate. It is seen more in bulky and short types of palate. Thus, taking into consideration all the metric measurements of the above study, we can state that advanced stage of OSMF patients have more likely susceptibility to cause OSA.

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