ORIGINAL ARTICLE

Cephalometric Association Between Various Shapes of Soft Palate with Different Growth Pattern and Age Groups in Skeletal Class I, II and III Malocclusion

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OBJECTIVE: The aim of this study was to find cephalometric association between various shapes of soft palate with different growth pattern and age groups in skeletal class I, II and III malocclusion.
METHODOLOGY: The pretreatment lateral cephalograms of 382 patients was collected from the department of Orthodontics, Liaquat College of Medicine & Dentistry, Karachi. The study included 96 males and 286 females between the ages of 11 to 30 years. All the patients were divided according to skeletal classification of malocclusion. The type of skeletal malocclusion, growth pattern and the morphological variations of soft palate were assessed. The differences in the proportion of soft palate morphology among skeletal malocclusion and growth pattern were calculated. Variation of the soft palate morphology among the genders and different age groups were also determined.
RESULTS: Subjects with Type 1 "leaf-shaped" soft palates were more prevalent (43.2%) whereas, The Type 4 "Straight-line" soft palate was least common (2.9%). Type 1 "leaf-shaped" soft palate was the most common in all skeletal malocclusion classes, growth pattern types and both genders.
CONCLUSION: This study found significant association between soft palate morphology with type of skeletal malocclusion and gender. No significant association found between soft palate morphology and types of growth pattern.
KEYWORDS: soft palate shapes, growth pattern, age groups, skeletal malocclusion, lateral cephalogram.
HOW TO CITE: Ismail N, Shaikh A, Khan SA. Cephalometric Association between various shapes of soft palate with different growth pattern and age groups in skeletal class I, II and III malocclusion. J Pak Dent Assoc 2023;32(3):85-90.
DOI: https://doi.org/10.25301/JPDA.323.85
Received: 23 August 2022, Accepted: 26 December 2023

INTRODUCTION

The soft palate is the posterior fibromuscular portion of the palate. The soft palate divides the nasopharynx and oropharynx.[1] It performs normal tasks such as deglutition, breathing, and phonation.[1] It is involved in most oral functions, including velopharyngeal closure, which is associated with normal sucking, swallowing, blowing, and pronunciation.[2]

The velopharyngeal closure system is composed of the velar and pharyngeal structures. The proportions, structure and dynamics of the soft palate, is an essential component in performing the functions together with the airway. Any abnormality could result in misarticulation, errors in phonation and hypernasality.[3] The morphology of the soft palate plays an important part in the velopharyngeal closure.[4] Soft palate abnormalities is commonly found in individuals with the cleft palate and lip, swollen adenoids, obstructive sleep apnea syndrome, snoring, poor maxillary dentures preservation, and skeletal malocclusions.[5] Therefore, natural morphology and every other soft palate anomaly will aid in the diagnosis and effective treatment of such difficult cases.[6] Since the soft palate is anatomically located posteriorly, the inaccessibility of the velopharyngeal area makes it impossible for clinical evaluation, and so alternative methods of examination are needed to examine the soft palate.[1] Soft palate assessment on lateral cephalogram is a simple, inexpensive, and readily accessible technique.[1]

You et al. in their research found that the soft palate configuration appeared differently in normal individuals and concluded that it is unreasonable to classify the soft palate morphology as just one type as traditionally believed.

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They also noticed that previous investigators have not identified all forms found in their research.[7] Pépin et al. only observed a "Hooked" appearance of the soft palate. This hooked structure of the soft palate was designated as "Type 5" by you et al.11 They found six morphological variations of soft palate: 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 observation of the soft palate on lateral cephalograms.[1,5,7,8]

Normal soft palate function is usually not accomplished sometimes after the soft tissue defect has been repaired in cleft cases. Velopharyngeal insufficiency (VPI) with hypernasal speech results in 30% or more of individuals.[2] Cohen et al. proposed that one of the possible causes for this surgically effective but functionally limited restoration might be the difference in soft palate morphology.[2] The morphological diversity of the soft palate might be a possible justification for surgical failure, and the soft palate might be addressed in a number of different ways.[2]

Malocclusion can manifest itself in a variety of ways and is commonly found in individuals with cleft lip and palate, swollen adenoids, OSAS, and snoring.[2] Numerous experiments including Samdani et al, Jayaparkash et al, You et al and few others have been performed in the past with regard to the proportional study of the soft palate and its adjacent components, but less consideration has been given to the morphological variations of the soft palate and its structure related to skeletal malocclusion with different growth patterns.[2,3,5,7,9] The aim of this study was to find cephalometric association between various shapes of soft palate with different growth pattern and age groups in skeletal class I, II and III malocclusion.

METHODOLOGY

Source of Data

The study was conducted on patients visiting the department of Orthodontics, Liaquat College of Medicine and Dentistry, Karachi. Duration of study was 6 months (1st January 2022- 30th June 2022). Three hundred and eighty two subjects, between 11-30 years of age seeking orthodontic treatment for malocclusion, were included in this descriptive cross-sectional study. The ethical committee of the institute issued the ethical certificate (IRB/D-000022/21) to conduct this study. Pre-treatment lateral cephalogram of each subject was obtained.

Inclusion criteria

Patients of both genders with the age range of 11 to 30 years, seeking fixed orthodontic treatment with normal speech were included in the study.

Exclusion criteria

Lateral cephalogram with unclear and distorted images. Patients with cleft lip and palate, any speech abnormality, head and neck anomalies, syndromes or any other systemic diseases, any history of trauma, fractures or recent extractions and patients with history of previous orthodontic treatment or orthognathic surgery were excluded in the study.

Method of collection of data

Lateral cephalogram of all patients were taken in standardized manner in natural head posture. The soft palate

Figure 1: Types of soft palate on the basis of shape

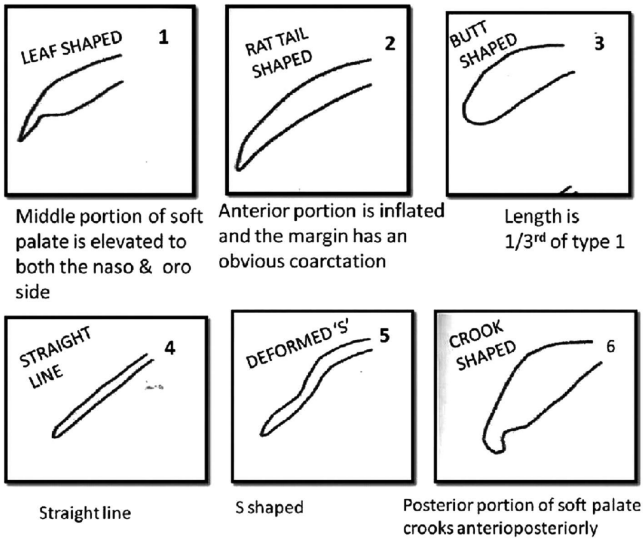
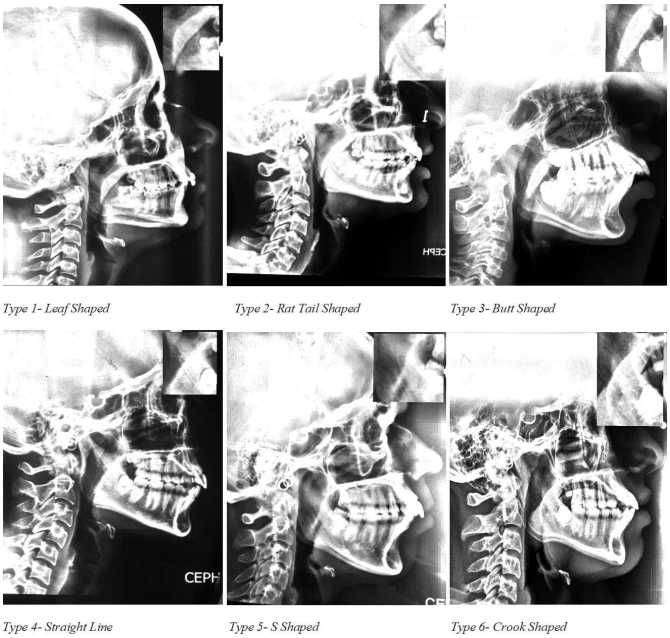


Figure 2: Velar Morphology on Lateral Cephalogram



morphological variations were assessed on lateral cephalogram and were assigned to one of the six different patterns described by You et al.[7] as shown in Figure 1 & 2. The differences in the frequency of each type were assessed among skeletal class malocclusion with different growth patterns. Types of malocclusion and soft palate morphology between the genders were also studied. Diagnostic histories from the orthodontic record files were verified to see whether patients have a para-functional habit of mouth breathing or not. The results were statistically analyzed to determine whether there is an association between soft palate variations and types of skeletal classification of malocclusion and growth pattern. The Steiner's measurements were used to select skeletal class of malocclusion i.e. Class I (ANB ±2°), Class II (ANB ≥4°) and Class III (ANB ≤0°).16 Tweed's FMA and SNMP measurements were used to select growth pattern i.e. Normodivergent (FMA 25°±4° & SNMP 32°±4°), Hypodivergent (FMA ≤20° & SNMP ≤27°) and Hyperdivergent (FMA ≥30° & SNMP ≥37°).[3,16,17]

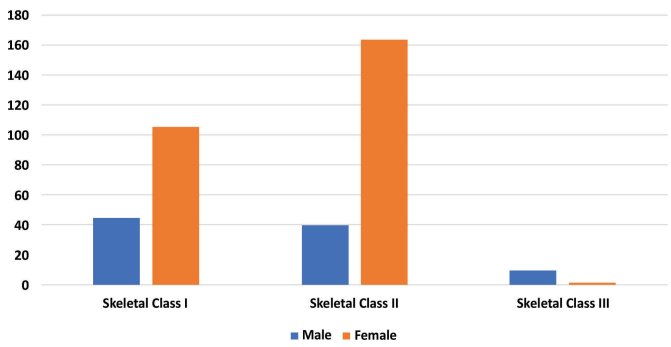
Statistical Analysis

- The data analysis was done by using SPSS version 26 and the statistical significance was tested at 5% level. A cross-tab was designed by categorizing the individuals based on the type of skeletal malocclusion, the type of growth pattern and the shape of soft palate.
- Chi-square test was used to appraise the association and Pearson's correlation was used to test the correlation among the variables in the cross-tabs.

RESULTS

In the present study, the lateral cephalograms were categorized according to skeletal class malocclusion. Skeletal class II was the most prevalent among all subjects, accounting for 53.7%, followed by class I (39.5%), and class III (6.8%). The types of skeletal malocclusion were significantly correlated (p-value ≤0.05) between the genders. Skeletal class I was most prevalent in males (46.9%), whereas skeletal class II was most prevalent in females (57.3%) as shown in [Figure 3].

Figure 3: Skeletal Malocclusion & Gender Cross Tabulation



On the basis of types of growth pattern, the normodivergent growth pattern was found to be the most common (52.1%), followed by hyperdivergent (29.6%) and hypodivergent growth patterns (18.3%).

The normodivergent growth pattern was relatively common in skeletal classes I and II, whereas the hyperdivergent growth pattern was more common in skeletal class III.

It was found that there is a positive co-relationship between skeletal class and growth pattern (p-value ≤0.05) as seen in the [Table I].

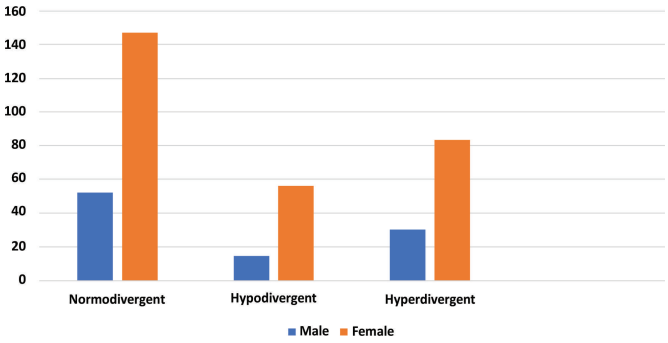
Table I: Skeletal Class & Growth Pattern Relationship

Skeletal Class	Growth Pattern n (%)			Total	*p-Value*
	Hypodivergent	Normodivergent	Hyperdivergent		
Skeletal Class I	33 (21.9)	92 (60.9)	26 (17.2)	151	0.001
Skeletal Class II	32 (15.6)	97 (47.43)	76 (37.1)	205	
Skeletal Class III	5 (19.2)	10 (38.5)	11 (42.3)	26	

p-value ≤0.05 = Statistically Significant

[Figure 4] shows that the types of growth pattern were insignificantly correlated (p-value ≥0.05) between the genders. In our study, we analyzed the morphologies of the soft palate on lateral cephalogram and found that Type 1 "Leaf shaped" soft palate was most common among the individuals (43.2%),

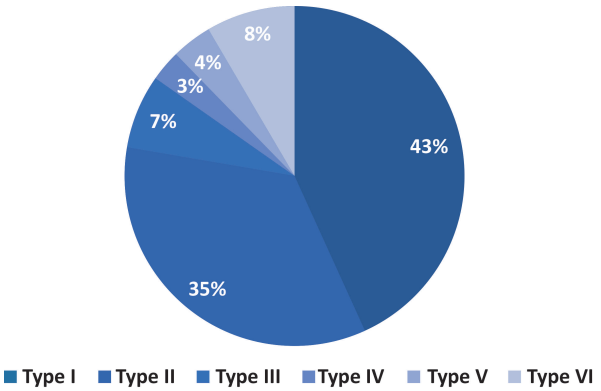
Figure 4: Growth Pattern & Gender Cross Tabulation



followed by Type 2 "Rat tail" soft palate (34.6%). Type 3 "Butt shaped" found among (7.1%). Type 4 "Straight-line" was reported in (2.9%) of the cases. Type 5 "S-shaped" observed in (3.9%). Type 6 "Crook shaped" was presented in (8.4%) s can be seen in the [Figure 5].

This study found a significant association between skeletal class and soft palate morphology (p-value ≤0.05). As shown in the [Table II], Type 1 "Leaf shaped" was commonly found among all three skeletal classes i.e. skeletal

Figure 5: Variants of soft palate



Class I malocclusion (42.4%), skeletal Class II malocclusion (42%), and skeletal Class III malocclusion (57.7%). Type 1 "Leaf-shaped" soft palate was typical in all types of growth pattern.

However, no significant relationship between growth pattern and soft palate morphology was established (p-value ≥0.05) as given in the [Table III].

The morphologies of soft palate were suggestively associated (p-value ≤0.05) among both genders. [Table IV]. The frequency of the Type 1 "leaf shaped" soft palate was highest in both males (45.8%) and females (42.3%), whereas the frequency of Type 4 "Straight-line" soft palate variant was lowest in both males (1.0%) and females (3.5%).

Table II: Correlation of Soft palate variants with different skeletal class malocclusion

Skeletal Malocclusion	Leaf shaped	Rat tail shaped	Butt like	Straight line shaped	S shaped	Crook shaped	Total	*P-Value*
Skeletal class I malocclusion	64	45	16	7	6	13	151	
Skeletal class II Malocclusion	86	83	11	4	5	16	205	0.004
Skeletal class III Malocclusion	15	4	0	0	4	3	26	
Total n (%)	165 (43.2)	132 (34.6)	27 (7.1)	11 (2.9)	15 (3.9)	32 (8.4)	382 (100)	

p-value ≤0.05 = Statistically Significant

Table III: Correlation of Soft palate variants with different Growth pattern

Growth Pattern	Leaf shaped	Rat tail shaped	Butt like	Straight line shaped	S shaped	Crook shaped	Total	*P-Value*
Hypodivergent	35	22	7	1	2	3	70	
Normodivergent	87	69	13	7	4	19	199	0.276
Hyperdivergent	43	41	7	3	9	10	113	
Total n (%)	165 (43.2)	132 (34.6)	27 (7.1)	11 (2.9)	15 (3.9)	32 (8.4)	382 (100)	

p-value ≥0.05 = Statistically Insignificant

The age-wise comparison (<20 years and >20 years) in the current study found almost equal proportions of Type 1 (Leaf shaped), Type 3 (Butt like) and Type 6 (Crook shaped)

Table IV: Distribution of Soft palate shapes among Genders

Variants of soft palate	Male n (%)	Female n (%)	*P-Value*
Leaf shaped	44 (45.8)	121 (42.3)	
Rat tail shaped	23 (24.0)	109 (38.1)	
Butt like	7 (7.3)	20 (7.0)	0.002
Straight line shaped	1 (1.0)	10 (3.5)	
S shaped	4 (4.2)	11 (3.8)	
Crook shaped	17 (17.7)	15 (5.2)	

p-value ≤0.05 = Statistically Significant

Table V: Distribution of Soft palate shapes among different Age Groups

		Soft Palate Shapes							
Age Groups		Leaf shaped n (%)	Rat tail shaped n (%)	Butt like n (%)	Straight line shaped n (%)	S shaped n (%)	Crook shaped n (%)		*P*-Value
	<20 Years	120 (42.1)	107 (37.5)	20 (7.0)	5 (1.7)	10 (3.5)	23 (8.0)	285	0.118
	>20 Years	45 (46.3)	25 (25.7)	7 (7.2)	6 (6.1)	5 (5.1)	9 (9.2)	97	
Total		165	132	27	11	15	32	382	

p-value ≥0.05 = Statistically Insignificant

soft palate in the study sample with no significant association between age group and soft palate morphology (p-value ≥0.05) as summarized in the [Table V].

Considering the history of any parafunctional habit, mouth breathing was frequently present among skeletal class II malocclusion with normodivergent growth pattern having Type 2 "Rat tail" soft palate.

However, the correlation of mouth breathing with skeletal class, growth pattern and soft palate morphology is negatively correlated (p-value ≥0.05).

DISCUSSION

Lateral cephalogram is the most widely used diagnostic radiograph in clinical orthodontics.[2] It helps in the evaluation of soft tissues and associated craniofacial structures. Miles et al. (1995) proposed that linear measurements on a cephalogram, such as minimal pharyngeal airway space, soft palate thickness, and hyoid bone position which contributes to the formation of upper airway can be reliably identified on cephalogram.[1,14] It is a generally accepted tool for assessing the soft palate in individuals with normal anatomy and those with a cleft palate or obstructive sleep apnea syndrome (OSAS).[1]

The soft palate plays a key role in velopharyngeal closure.[2] Velopharyngeal insufficiency occurs when the soft palate fails to separate the oral cavity from the nasal cavity during speech and swallowing.[4] This might be related to differences in the shapes of the soft palate.[7] You et al, classified soft palate morphologies in six types on the basis

of various radiographic appearances, the most common of which is Type 1 "Leaf-shaped" (53%).[7] Awati et al. (50%)[1] and Vani et al(55%)[5] also determined that "Leaf shaped" had the highest probability among the samples. The results of the present study showed "Leaf-shaped" soft palate as the most common type being present in 43.2% of individuals. However, in the surveys conducted by Samdani D et al. (37.2%)[2], Nandhini et al. (40.4%)[9] and Chandan et al. (35.0%)[4], "Rat tail-shaped" was reported to be the most common type of soft palate.

Malocclusion is common in patients with soft palate dysfunction, cleft lip and palate, swollen adenoids, and OSAS. In the present study, ANB angle, which is most widely used to determine the anteroposterior dentofacial discrepancy, was evaluated to classify the skeletal malocclusion. Skeletal class II malocclusion was more prevalent among all subjects, accounting for 53.7%, followed by class I (39.5%), and class III (6.8%). Comparing the malocclusion with soft palate morphology, Bhambri et al. stated that soft palate morphologies and malocclusions are significantly related. His results showed that "Leaf-shaped" soft palates are more common in skeletal class I (57.8%), whereas "Rat tail-shaped" soft palates are more common in skeletal class II (55.5%).[6] However, in our study, patients with skeletal class I and class II malocclusion were most commonly reported to have "Leaf-shaped" morphology of the soft palate. The relationship between soft palate and skeletal malocclusion was also found to be significant with p-value of <0.05.

When both genders were compared, Awati et al. discovered a statistically significant association between soft palate morphology and genders.[1] In contrast, Samdani D et al. found this relation to be non-significant (p-value >0.05).[2] He observed "Rat tail-shaped" soft palate more frequent in both the genders but we have found "Leaf-shaped" soft palate was more prevalent in both genders, 45.8% and 42.3% males and females, respectively. The current study established that shapes of soft palate were suggestively correlated (p-value <0.05) among both the genders.

When age groups with various soft palate morphologies were compared, Chandan et al.[4] found the relation was statistically insignificant. This result was in consistent with researches done by Nagaraj et al.[17] and Sprenger et al.[18] We also found statistically insignificant association between age group and soft palate morphology (p-value>0.05). Obstructive sleep apnea (OSA) is characterized by recurrent upper airway blockage caused by the inspiratory collapse of the pharyngeal walls during sleep.[2] When association of OSA with soft palate morphology was assessed, Samdani D et al. proposed that during adulthood, there is a tendency toward a longer and wider soft palate and a narrower oropharynx, which may increase the occurrence of OSA and related illnesses.[2] Based on the findings on different velar dimensions, Johnston CD et al.[10] concluded that a small bony pharyngeal skeleton and a narrow oropharyngeal airway lead to the development of obstructive sleep apnea in adulthood. Pépin et al. identified a "Hooked" appearance of the soft palate in their study, indicating a significant risk for OSAS.[11] You et al, classified this hooked structure of the soft palate as "Type 5".[7] The present study found "Hooked shaped" soft palate only in a few cases (3.9%) which was in agreement with the study performed by Jayaprakash et al (1%).[3]

Different growth patterns may affect the morphology of soft palate. Sprenger et al. reported in a cephalometric study, that there is significant inconsistency in linear space measurement posterior to the palate in the oropharynx region.[18] This was discovered to be more prevalent in patients with hyperdivergent growth pattern.[3] Jayaprakash et al. had shown that the individuals with hyperdivergent growth pattern and "Crook shaped" soft palate were seen to be more predisposed to obstructive sleep apnea.[3] The results of current study showed "Leaf-shaped" soft palate was typical in all types of growth patterns but the association between growth pattern and soft palate morphology was statistically insignificant. (p-value=0.276).

Skeletal class II malocclusion and vertical growth patterns have been linked to upper and lower pharyngeal airway obstruction and mouth breathing.[13] This suggests that, in skeletal class II malocclusion, individuals may have relative or absolute mandibular deficiency which may predisposes them to pharyngeal airway obstruction and mouth breathing.[13] In our study, we commonly found a history of mouth breathing among patients with skeletal class II malocclusion and normodivergent growth patterns. The "Rat tail-shaped" soft palate was found to be more prevalent among the patients with mouth breathing. However, the correlation of mouth breathing with skeletal class, growth pattern and soft palate morphology was negatively correlated (p-value >0.05). The current study might be viewed as a preliminary attempt to characterize the types of soft palate. Considering the findings of our study, the soft palate morphology associated with velopharyngeal insufficiency and sleep apnea can be recognized.

LIMITATIONS

This study used a two dimensional digital lateral cephalogram, which was a limitation. Three-dimensional imaging with CBCT would help assess the soft palate proportions as well as its morphology. This will facilitate the formulation of an appropriate treatment plan and will

complement the findings of our research.

The uneven distribution of the samples constituted the study's shortcomings as well. A sample distribution that is equitable would be more validating.

CONCLUSION

This study aimed to evaluate the variations of soft palate morphology. Type 1 "Leaf-shaped" soft palate was found to be the most recurrent category in all three skeletal classes of malocclusion, irrespective of gender distribution. The association of velar morphology with skeletal malocclusion and both genders was statistically significant. The velar morphology does not show similar association with different age groups and growth patterns. This radiographic classification of velar morphology can be helpful in the diagnosis and treatment of OSA and cleft patients both anatomically and functionally.

ACKNOWLEDGEMENT

I would like to thank my supervisor for bringing the weight of her considerable experience and knowledge to this article. Her guidance and advice carried me through all the stages of writing my article.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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