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Lingual frenulum length: A prospecting link to craniofacial morphology in adults

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Abstract

OBJECTIVES: The aim of this study was to evaluate the correlation of the length of the lingual frenulum with the craniofacial morphology in adults.

METHOD AND MATERIALS: The study comprised a total of 144 subjects, aged 18 to 28 years, divided into 3 groups (48 in each group), based on ANB angle i.e., Skeletal Class I, Skeletal Class II & Skeletal Class III. To measure the length of the lingual frenulum direct and indirect methods were used. A Lingual frenulum ruler was used for direct measurement and the differences between the maximum mouth opening reduction (MMOR) with and without the tip of the tongue touching the incisive papilla measurement were taken for the indirect method. A lateral cephalogram was collected from each subject and a cephalometric analysis was done to assess craniofacial morphology. Statistical analysis was done by ANOVA and the significance of the mean difference between (inter) the groups was done by Tukey's HSD (honestly significant difference) post hoc test after ascertaining normality by Shapiro-Wilk's test and homogeneity of variance between groups by Levene's test

RESULTS: The lingual frenulum length and maximum mouth opening reduction were significantly increased in the Skeletal Class III subjects with a statistically significant value of $P < 0.001$ when compared with the Skeletal Class I and Skeletal Class II subjects.

CONCLUSION: A balance in the teeth positioning is maintained by orofacial musculature and any disturbance which occurs in this, results in malocclusion. Malocclusion can result in a long lingual frenulum that pushes the mandibular anterior forwards. Hence, the malocclusion and lingual frenulum length relationship are essential to eliminate the erratic forces and to attain excellent results, following the elimination of malocclusion.

Keywords:

Craniofacial morphology, lingual frenulum, malocclusion, maximum mouth opening reduction, tongue

Introduction

The correlation of soft tissue arrangement and genetics with malocclusion has been shown in various literature.[1-3] Orofacial musculature growth and development act as an important factor in the management of different malocclusion.[4] The tongue is an important structure in the oral cavity as it helps in speech, deglutition, and mastication. It also plays a role in dentofacial growth, facial development, and the development of occlusion.[5] Change in tongue posture can lead to malocclusions.[6,7]

Frenulum is a tissue fold present in the oral cavity. It attaches the alveolar bone to the lip, tongue, and buccal mucosa. The Midline frenum, bilateral buccal frenum, and lingual frenum are the frenulums present in the oral cavity.[8] Their functions include maintaining a balance between the lip, growing bones and tongue during fetal growth, and also controlling lip, tongue, and cheek movement.[9,10] Abnormal frenum can

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affect lip, tongue, and cheek movement and thus lead to abnormal teeth positioning and jaw position.

The lingual frenum is a midline structure that extends from the floor of the mouth to the ventral surface of the tongue[11] Frenulum length and degree of attachment influence tongue mobility.[12] Lingual frenum should not be restrictive as it will affect the posture of the tongue, swallowing pattern, and speech pattern.

Previous literature has shown a correlation of maxillary labial frenum with midline diastema and their subsequent relapse,[13] but very little evidence is present about the lingual frenulum. Keim[10] in his editorial, affirms the need for the lingual frenulum. research[14,15] Hence, the aim of the study was to determine the correlation of the length of the lingual frenulum with the craniofacial morphology in adults.

Method and Materials

The study comprised 144 subjects between the age group of 18-28 years. Subjects included both genders and were collected from the North Indian population. The study design was reviewed and approved by the institutional ethical committee under file no. 02/IEC/RDCHRC/2018-19 and written informed consent was obtained from the study participants. All the measurements were performed. The exclusion criteria for the study were occlusal trauma, masticatory disharmony or clinically diagnosed temporomandibular joint disorders, previous orthognathic surgery, occlusal adjustment or orthodontic treatment, tongue-tie condition, previous lingual frenectomy, or macroglossia and macroglossia. The distribution of age and sex in different groups were shown in Table 1. Based on the ANB angle, subjects were divided into 3 groups which are skeletal Class I (0° <ANB <4°) 48 subjects, skeletal Class II (ANB angle >4°) 48 subjects, and skeletal Class III (ANB angle <0°) 48 subjects.

Two different methods of anatomical measurements of the length of the lingual frenulum: Direct method: The length of the lingual frenulum was measured directly with a lingual frenulum ruler according to the procedure proposed by Lee *et al*.[17] The patient was asked to open the mouth to maximum width and place the tip of the tongue at the incisive papillary region. The median lingual frenulum length (MLFL) was measured with the ruler. The isthmus of the ruler was fully inserted and the other side of the ruler touched the lower anterior teeth [Figure 1a] the distance between the lingual frenulum's uppermost point and its insertion into the oral floor was measured to determine the vertical lingual frenulum length (VLFL) [Figure 1b]. and Indirect technique which was evaluated indirectly by measuring the differences between the maximum mouth opening with and without the tip of the tongue touching the incisive papilla.

Table 1: Demographic characteristics (Mean±SD) of three groups of craniofacial morphology

Variable	Class I (*n*=48) (%)	Class II (*n*=48) (%)	Class III (*n*=48) (%)	F/χ^2	*P*
Age (yrs)	22.56±2.45	21.63±2.54	21.98±2.69	1.64	0.198
Sex:					
Female	28 (58.3)	29 (60.4)	25 (52.1)	0.74	0.692
Male	20 (41.7)	19 (39.6)	23 (47.9)		

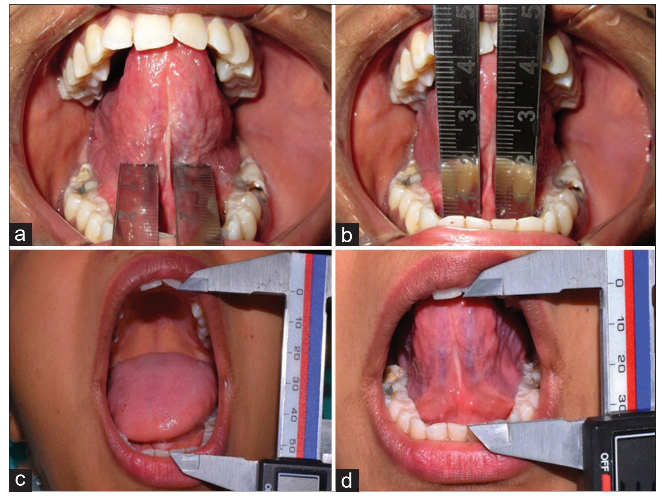

Figure 1: (a) Representing the measuring procedure of median lingual frenulum length, (b) Representing the measuring procedure of vertical lingual frenulum length, (c) Representing the maximum mouth opening without tip of tongue touching the incisive papilla, (d) Representing the maximum mouth opening with tip of tongue touching the incisive papilla

Measurement of maximum mouth opening reduction (MMOR): The maximum mouth opening reduction was recorded using a digital vernier caliper with a resolution of 0.01 mm. Firstly, the patient was asked to open their mouth as wide as possible and the inter-incisal measurement was determined [Figure 1c]. The patient was then asked to place the tip of the tongue on the incisive papilla and the interincisal distance at this position was recorded again [Figure 1d]. The reduced amount of maximum mouth opening was then calculated by the difference between the two measurements. These measurements were used to eliminate errors that could happen from the difference in the absolute value of maximum mouth opening from the individual variation of a mandibular function.

Cephalometric analysis: A lateral cephalogram was taken for each subject and a cephalometric analysis was carried out. Parameters such as ANB angle were used for the evaluation of the craniofacial morphology.

Statistical analysis

Data were summarized as Mean ± SD (standard deviation). Groups were compared by one-factor analysis of variance (ANOVA) and the significance of the mean difference between (inter) the groups was done by Tukey's HSD (honestly significant difference) post hoc test after ascertaining normality by Shapiro-Wilk's test and homogeneity of variance between groups by Levene's test. Categorical groups were summarized in number (n) and percentage (%) and compared by the Chi-square (χ^2) test. A two-tailed ($\alpha = 2$) $P < 0.05$ was considered statistically significant. Analyses were performed on SPSS software (Windows version 17.0).

Results

Comparing the mean age of the three groups, ANOVA showed similar age among the groups (F = 1.64, $P = 0.198$) i.e., did not differ significantly [Table 1]. Comparing the sex (M/F) frequency of the three groups, the χ^2 test showed similar sex frequency among the groups ($\chi^2 = 0.74$, $P = 0.692$) i.e., also did not differ significantly. In other words, subjects of the three groups were age and sex-matched and thus may not influence the study variables (MMOR, MLFL, and VLFL) [Table 1].

The maximum mouth opening (MMOR) of three groups (Skeletal Class I, Skeletal Class II, and Skeletal Class III) is summarized in Table 2 and also depicted in Figure 2. The mean MMOR in Skeletal Class I, Skeletal Class II, and Skeletal Class III was 15.35 ± 3.77, 16.10 ± 3.82, and 21.16 ± 5.16 mm respectively. The MMOR of Skeletal Class III was the highest followed by Skeletal Class II and Skeletal Class I the least (Skeletal Class III > Skeletal Class II > Skeletal Class I). Comparing the mean MMOR of the three groups, ANOVA showed significantly different MMOR among the groups (F = 25.89, $P < 0.001$) [Table 2]. Further, comparing the difference in mean MMOR between the groups, the Tukey test showed significantly ($P < 0.001$) different and higher MMOR of Skeletal Class III as compared to both Skeletal Class I and Skeletal Class II [Table 3]. However, it did not differ ($P > 0.05$) between Skeletal Class I and Skeletal Class II i.e., found to be statistically the same.

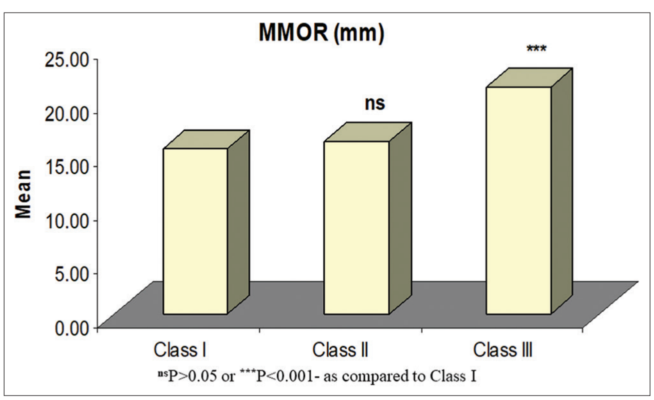

Figure 2: Maximum mouth opening reduction of three groups of craniofacial morphology

The median lingual frenulum length (MLFL) of three groups (Skeletal Class I, Skeletal Class II, and Skeletal Class III) is summarized in Table 4 and also depicted in Figure 3. The mean MLFL in Skeletal Class I, Skeletal Class II, and Skeletal Class III were 3.42 ± 1.50, 2.40 ± 1.66, and 5.50 ± 2.66 mm respectively. The MLFL of Skeletal Class III was the highest followed by Skeletal Class I and Skeletal Class II the least (Skeletal Class III > Skeletal Class I > Skeletal Class II). Comparing the mean MLFL of the three groups, ANOVA showed significantly different MLFL among the groups (F = 29.90, $P < 0.001$) [Table 4]. Further, comparing the difference in mean MLFL between the groups, the Tukey test showed significantly ($P < 0.001$) different and higher MLFL of Class III as compared to

Table 2: Maximum mouth opening reduction (MMOR) (Mean±SD, *n*=48) of three groups of craniofacial morphology

Group	MMOR (mm)	*F*	*P*
Class I	15.35±3.77	25.89	<0.001
Class II	16.10±3.82		
Class III	21.16±5.16		

Table 3: Comparison of difference in mean MMOR between three groups of craniofacial morphology by Tukey test

Comparison	Mean difference	q	*P*	95% CI of difference
Class I vs. Class II	-0.74	1.20	*P*>0.05	-2.825 to 1.342
Class I vs. Class III	-5.80	9.35	*P*<0.001	-7.887 to -3.721
Class II vs. Class III	-5.06	8.15	*P*<0.001	-7.146 to -2.979

Table 4: Median lingual frenulum length (MLFL) (Mean±SD, *n*=48) of three groups of craniofacial morphology

Group	MLFL (mm)	*F*	*P*
Class I	3.42±1.50	29.90	<0.001
Class II	2.40±1.66		
Class III	5.50±2.66		

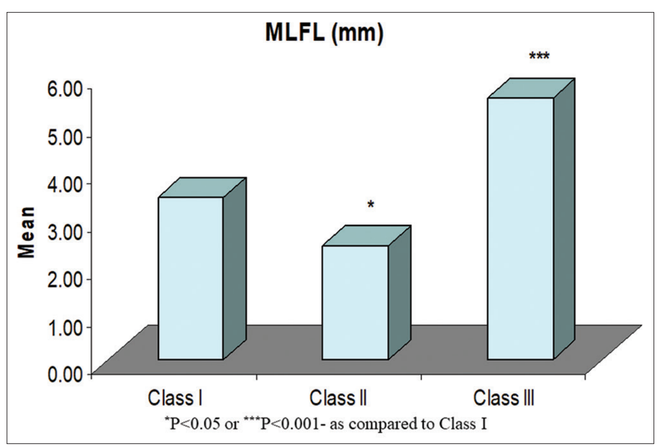

Figure 3: Median lingual frenulum length of three groups of craniofacial morphology

both Class I and Class II [Table 5]. Further, it was also found significantly ($P < 0.05$) different and higher in Skeletal Class I as compared to Skeletal Class II.

The vertical lingual frenulum length (VLFL) of three groups (Skeletal Class I, Skeletal Class II, and Skeletal Class III) is summarized in Table 6 and also depicted in Figure 4. The VLFL in Skeletal Class I, Skeletal Class II, and Skeletal Class III was 12.15 ± 3.20, 10.27 ± 3.04, and 15.27 ± 3.43 mm respectively. The VLFL shows an identical trend as MLFL i.e., highest in Skeletal Class III then Skeletal Class I and then Skeletal Class II (Skeletal Class III > Skeletal Class I > Skeletal Class II). Comparing the mean VLFL of the three groups, ANOVA showed significantly different VLFL among the groups ($F = 29.45$, $P < 0.001$) [Table 6]. Further, comparing the difference in mean VLFL between the groups, the Tukey test showed significantly ($P < 0.001$) different and higher VLFL of Class III as compared to both Class I and Class II [Table 7]. Further, it was also found significantly ($P < 0.05$) different and higher in Class I as compared to Class II.

Discussion

The study gives us important information about the relationship between the length of the lingual frenulum and malocclusion. Many theories have been explained in the past literature about the etiology of malocclusion. Most of the study states that genetics is the main etiology for malocclusion[16-19] but recently great emphasis is given to environmental factors.[1-3,10] The purpose of this study was to identify and correlate the relationship of the length of the lingual frenulum with the craniofacial morphology in adults. The present study demonstrated that there is an exploring link between craniofacial morphology and lingual frenulum length. The statistical evaluation showed that the median and vertical lingual frenulum length and maximum mouth opening reduction to be significantly ($P < 0.001$) increased in Class III Skeletal malocclusion. This suggested that patients with increased MLFLs and VLFLs are prone to the development of skeletal class III malocclusion.

According to Moss and Rankow's[20] functional matrix hypothesis, "the soft tissue units guide the hard tissue to an extent that renders skeletal genes superfluous." The growth of soft tissues has a very strong influence on hard tissue growth.[20] The tongue is also a soft tissue component that can influence maxillary and mandibular growth.[2] The equilibrium between the tongue and buccinators is responsible for the normal arch width development.[6]

The lingual frenulum is a midline structure extending from the floor of the mouth to the ventral surface of the tongue. It helps in tongue mobility.[11] The topic of the tongue and its role in malocclusion has endured a long history of professional discussion but very little literature exists showing the relationship of lingual frenum with malocclusion. The results of the current study for the evaluation of the prospecting link between lingual frenulum length and craniofacial morphology correlate with the Jang, *et al*.[21] a study that investigated the relationship between the lingual frenulum and craniofacial morphology. They stated that skeletal Class III malocclusion is related to long lingual frenulum and reduced maximum mouth opening. These findings also agreed with the Azizi *et al*.,[22] Meenakshi S and Jagannathan N[23] studies which assessed lingual frenulum lengths in different skeletal malocclusion.

Table 5: Comparison of difference in mean MLFL between three groups of craniofacial morphology by Tukey test

Comparison	Mean difference	q	*P*	95% CI of difference
Class I vs. Class II	1.02	3.53	*P*<0.05	0.050 to 1.992
Class I vs. Class III	-2.08	7.20	*P*<0.001	-3.054 to -1.112
Class II vs. Class III	-3.10	10.73	*P*<0.001	-4.075 to -2.133

q: Tukey test value, CI: confidence interval

Table 6: Vertical lingual frenulum length (VLFL) (Mean±SD, *n*=48) of three groups of craniofacial morphology

Group	VLFL (mm)	*F*	*P*
Class I	12.15±3.20	29.45	<0.001
Class II	10.27±3.04		
Class III	15.27±3.43		

Table 7: Comparison of difference in mean VLFL between three groups of craniofacial morphology by Tukey test

Comparison	Mean difference	q	P	95% CI of difference
Class I vs. Class II	1.88	4.03	*P*<0.05	0.313 to 3.437
Class I vs. Class III	-3.13	6.71	*P*<0.001	-4.687 to -1.563
Class II vs. Class III	-5.00	10.74	*P*<0.001	-6.562 to -3.438

q: Tukey test value, CI: confidence interval

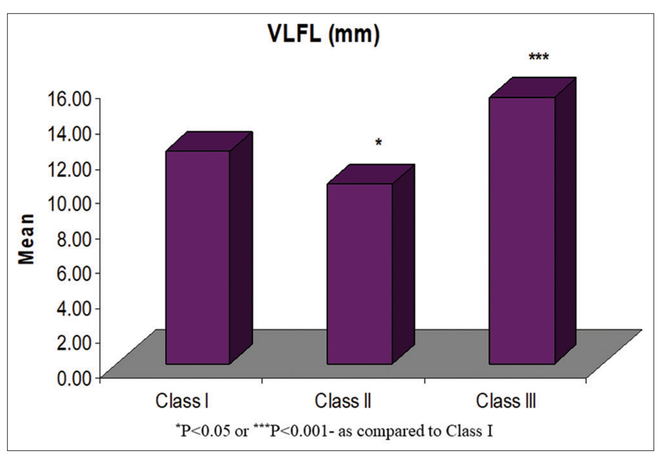

Figure 4: Vertical lingual frenulum length of three groups of craniofacial morphology

The study also showed convergent results with the finding of Sepet *et al*.[24] in which a significant positive correlation was found between the lingual frenulum length and irregular incisor. On the contrary, Mazzocchi and Clini[25] and Garcia Pola *et al*.[26] could not find any relation between the frenulum length and the occurrence of either dental or orthodontic anomalies.

The phenotype is inevitably the result of both genetic and environmental factors, to further clarify the role of the lingual frenulum, especially its relationship with mandibular prognathism in Skeletal Class III anomalies, future research is recommended to focus on long-term changes of craniofacial morphology.

Conclusion

This study investigated the relationship between the length of the lingual frenulum and craniofacial morphology. The lingual frenulum, a soft tissue mass that connects the floor of the mouth and the ventral surface of a tongue, exerts erratic forces on the mandible, thus influencing the development of the mandible from embryonic stages. This leads to skeletal malocclusion, with the degree being influenced by the different levels of attachment of the frenulum on the tongue. The present study showed that patients with class III malocclusion were associated with long frenulum lengths, which eventually led to the exertion of forces on the mandible, resulting in prognathism. This new finding will be helpful for clinicians concerning preventive orthodontics. Early diagnosis of frenulum length enables early correction or even prevents the chances of skeletal malocclusion. The prognosis of the treatment is also better, following corrections of lingual frenulum lengths in skeletal malocclusion.

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Conflicts of interest
There are no conflicts of interest.

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