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LIP-TOOTH ESTHETICS IN RELATION TO GROWTH PATTERNS: A CEPHALOMETRIC PERSPECTIVE

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ABSTRACT

Background: Lip–tooth esthetics plays a pivotal role in determining facial attractiveness. Maxillary incisor display and upper lip length are key determinants of smile esthetics and are influenced by underlying facial growth patterns. Understanding their relationship can aid in individualized orthodontic treatment planning. **Method:** A cross-sectional retrospective study was conducted on lateral cephalograms of 30 adult subjects aged 18–35 years. Participants were categorized into three groups based on Frankfort–mandibular plane angle (FMA): vertical growers, average growers, and horizontal growers (n = 10 each). Upper lip length (Sn–Stms) and incisor exposure (Stms–U1) were measured using Burstone analysis. **Result:** Upper lip length showed a statistically significant intergroup difference (p = 0.03), with vertical and average growers exhibiting greater values than horizontal growers. Incisor exposure was highest in vertical growers; however, no statistically significant difference was observed among the groups (p = 0.526). **Conclusion:** Facial growth pattern significantly influences upper lip length. To achieve optimal smile esthetics, soft tissue evaluation and growth pattern assessment should be incorporated in treatment planning.

KEYWORDS : Lip–tooth Esthetics, Facial Growth Pattern, Cephalometry, Upper Lip Length

INTRODUCTION

The lip-tooth relationship during speech and smiling is a critical component of facial esthetics.[1] The key determinants of an attractive smile is the amount of maxillary incisor crown exposure. Factors influenced for the same are upper lip length and incisor inclination.[2]

According to Enlow and Hans (1996), facial growth patterns are broadly classified as vertical (hyperdivergent), horizontal (hypodivergent), or average (normodivergent). They are determined primarily by the relationship between lower anterior facial height (LAFH) and posterior facial height (PFH), assessed clinically and cephalometrically. Vertical growers show increased LAFH and steep mandibular planes, horizontal growers have reduced LAFH with a flatter mandibular plane, and average growers fall within normal ranges. Growth patterns are influenced by genetic factors, condylar growth direction, dentoalveolar development, muscle function, and environmental influences.[3]

In orthodontics, smile analysis evaluates the posed smile primarily on two key parameters: the extent of incisal display and gingival display. An esthetically preferred posed smile is one in which the upper lip elevates just enough to reach the gingival margins of the maxillary incisors, thereby avoiding excessive gingival exposure.[1]

With increasing emphasis on smile esthetics in orthodontics, achieving a pleasing smile and optimal incisor display has become a primary treatment goal.[4] A cephalometric evaluation of these parameters across different growth patterns can provide valuable insights for personalized and aesthetically driven treatment planning.

The present study aims to evaluate the influence of different facial growth patterns on the positional relationship between the lips and anterior teeth using standardized cephalometric parameters, with the objective of providing data that can enhance aesthetically driven, individualised treatment planning.

MATERIALS AND METHODS

A cross sectional retrospective single centre study was conducted at Department of Orthodontics and Dentofacial Orthopedics, Kannur Dental College, Kannur on the lateral cephalogram of the adult patients aged between 18-35 years. The inclusion criteria for the study participants was the presence of all permanent teeth. Individuals presenting with any obvious pathology, those with any history of previous orthodontic treatment and those with anterior open bite affecting accurate measurement of incisor exposure were excluded from the study. Lateral cephalograms were thus selected and retrieved from the case record of patients visiting the department, based on random sampling. A total sample size of 30 was considered.

After sample selection, the cephalograms were divided into three groups based on growth pattern: Group A (Vertical growers), Group B (Average growers), Group C (Horizontal growers), with 10 subjects in each group. This was performed by assessing the Frankfort–mandibular plane angle (FMA). FMA was calculated as the angle formed at the intersection of Frankfort horizontal plane (Orbitale to Porion) and the mandibular plane (Gonion to menton) (Figure 1).

Cephalometric parameters considered for smile analysis in the present study includes incisor exposure and upper lip length. All lateral cephalograms were measured manually and calibrated at 10mm. Burstone analysis was performed for measuring incisor exposure by measuring the distance from Stm_s to U1. Upper lip length was measured as the distance from Sn to Stm_s(Figur 1).

These parameters with different facial growth patterns were then compared among the subjects.

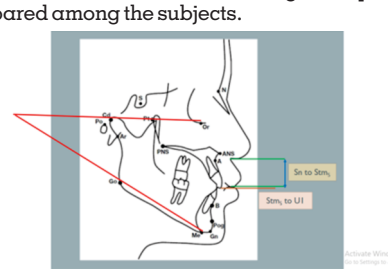

Figure 1: Schematic Diagram of Analyzed Parameters.

Statistical Analysis

Continuous variables including age, Frankfort–mandibular plane angle (FMA), lip length, and incisor exposure were expressed as mean ± standard deviation. Normality of the data was assessed using the Shapiro–Wilk test, which confirmed that all variables followed a normal distribution ($p > 0.05$). Intergroup comparisons were performed using one-way analysis of variance (ANOVA). For variables showing statistical significance, post-hoc Tukey HSD test was applied to identify pairwise differences. A p value < 0.05 was considered statistically significant.

RESULTS

The mean age among the subjects with average growth pattern, vertical growth pattern and horizontal growth pattern were 19.9 ± 1.91 years, 20.0 ± 2.31 years and 21.9 ± 2.81 years respectively. The mean FMA was highest in vertical growers (32.9 ± 1.73°), lowest in horizontal growers (18.0 ± 2.21°) and the average growers showed an intermediate value (25.9 ± 2.18°), as expected. Among the average growers, the mean lip length was 20.5 ± 2.51 mm and mean incisor exposure was 2.0 ± 1.63 mm. The vertical growth pattern group demonstrated a mean lip length of 21.7 ± 1.83 mm and mean incisor exposure of 3.1 ± 2.18 mm. In the horizontal growth pattern, the mean lip length was 19.4 ± 1.26 mm and mean incisor exposure was 2.1 ± 3.07 mm (Table 1).

Table 1. Descriptive Statistics of Study Variables According to Growth Pattern (n = 10 per group)

Growth Pattern	Variable	Mean	SD	95% CI (Lower–Upper)	Min	Max
Average	Age (years)	19.9	1.91	18.53 – 21.27	18	23
	FMA (°)	25.9	2.18	24.34 – 27.46	23	28
	Lip Length (mm)	20.5	2.51	18.71 – 22.29	15	24
	Incisor Exposure (mm)	2.0	1.63	0.83 – 3.17	0	6
Vertical	Age (years)	20.0	2.31	18.35 – 21.65	18	25
	FMA (°)	32.9	1.73	31.66 – 34.14	30	35
	Lip Length (mm)	21.7	1.83	19.39 – 22.01	16	22
	Incisor Exposure (mm)	3.1	2.18	1.54 – 4.66	0	8
Horizontal	Age (years)	21.9	2.81	19.89 – 23.91	18	27
	FMA (°)	18.0	2.21	16.42 – 19.58	14	20
	Lip Length (mm)	19.4	1.26	18.50 – 20.30	17	21
	Incisor Exposure (mm)	2.1	3.07	−0.10 – 4.30	0	8

One-way analysis of variance (ANOVA) was performed to compare the study variables among the average, vertical, and horizontal growth pattern groups (Table 2). The analysis revealed a statistically significant difference in FMA among the three groups ($F = 131.84$, $p < 0.001$). Post-hoc Tukey HSD analysis showed that the vertical growth pattern exhibited significantly higher FMA values, followed by the average growth pattern, with the horizontal growth pattern showing the lowest values. This significant p value indicates that the allocation of participants to the respective study groups were appropriate and unbiased.

Among the smile analysis parameters, the lip length showed a statistically significant intergroup difference ($F=2.98$, $p=0.03$), where the vertical and the average growth patterns exhibited a comparable values and were significantly greater than the horizontal growth pattern. In contrast, no statistically significant differences were observed among the groups with respect to incisor exposure ($p = 0.526$).

Table 2. One-way ANOVA with Post-hoc Tukey HSD Comparison Among Growth Patterns

Variable	Average Growth Pattern	Vertical Growth Pattern	Horizontal Growth Pattern	F value	p value	Post-hoc Tukey HSD
Age (years)	19.9 ± 1.91	20.0 ± 2.31	21.9 ± 2.81	2.26	0.124	—
FMA (°)	25.9 ± 2.18	32.9 ± 1.73	18.0 ± 2.21	131.84	< 0.001*	Vertical > Average > Horizontal
Lip Length (mm)	20.5 ± 1.51	21.7 ± 1.83	19.4 ± 1.26	2.98	0.03*	Vertical = Average > Horizontal
Incisor Exposure (mm)	2.0 ± 1.63	3.1 ± 2.18	2.1 ± 3.07	0.66	0.526	—

DISCUSSION

Historically, cephalometric analysis have predominantly emphasized skeletal relationships. Despite the fact that patients primarily seek orthodontic care to enhance their smiles, the orthodontic literature has traditionally prioritized skeletal parameters over smile related characteristics, resulting in comparatively limited focus on smile esthetics. Consequently, orthodontic treatment has long associated esthetic improvement chiefly with facial profile enhancement.[5]

In 1999 Jr Kokich VO et al explored how dentists, orthodontists, and laypersons perceive changes in dental esthetics, including alterations in midline deviation, tooth size, gingival display, and incisal edge asymmetry. The results showed that dental professionals were more sensitive to minor esthetic discrepancies than laypeople, however clinicians should be aware of these perceptual differences and balance professional standards with patient expectations during treatment planning.[6] Since early 2000, the contemporary orthodontics shifted the treatment focus to the attainment of a balanced attractive smile along with facial profile enhancement. Accordingly evaluation of the soft tissue profile, primarily through lateral cephalometric radiography has gained substantial importance.[7]

The successful management of smiles lies in multidisciplinary planning, precise diagnosis, and aligning treatment options with patient expectations for optimal esthetic and functional outcomes.[8] In 2013 Kaya B and Uyar R investigated how smile arc and gingival display together affect smile attractiveness. The results showed that smiles with a consonant smile arc and minimal gingival display were consistently rated as most attractive. In contrast, flat smile arcs and excessive gingival display reduced perceived attractiveness. The study concluded that since both smile arc and gingival display play a significant role in esthetic perception, they should be key considerations in orthodontic diagnosis and treatment planning.[9]

Numerous studies on lip- tooth relationships have been undertaken by orthodontists worldwide, revealing the importance of lip- tooth esthetics in orthodontics. The present study is conducted among the adult population of North Kerala (Malabar region). The choice to include individuals of age 18- 35 was to ensure that the soft tissue parameters attained a constant value. Age groups below 15 tend to show variations in the lip length.[7]

Ackerman MB etal analyzed the dynamic lip-tooth interactions. Authors measured lip movement and maxillary incisor exposure across different phonemes and smiling expressions and concluded that factors such as age, ethnic variations affect the lip-tooth relationship with class I skeletal pattern.[10] Hence region specific studies are imperative for a comprehensive understanding of ethnic variations, and the

present study aligns with this objective.

One among the notable Indian studies on the soft tissue profiles among the three facial types is the study by Khalid Ashraf et al. conducted in 2018. In this study, the authors highlighted that the proportions of nose, lips and chin are of at most importance to attain facial harmony in orthodontics and hence studying soft tissue patterns in the three mandibular divergent patterns is essential in orthodontic treatment choice. They could elucidate a statistically significant association of upper lip thickness and chin thickness with the three growth pattern. The chin thickness and upper lip thickness were less in vertical growers as compared to horizontal growers. Mean lip length studied among the three growers yielded a lesser value among horizontal growers. This is similar to the findings of the present study. However, this was not statistically significant in the former study, unlike the present study.[7]

The study conducted by Tiwari A and Jain RK on Lip- tooth relationships and various growth patterns also concluded that lip-tooth relationships are significantly influenced by vertical and horizontal growth patterns. The results were similar to the present study with an increased incisor exposure among vertical growers followed by horizontal growers and least in the average growers, although the mean was much higher (7.80> 6.90> 5.0) compared to our study (3.1> 2.1>2). The study found that vertical growth patterns may require special consideration during orthodontic treatment planning due to esthetic concerns. The authors also commented the lack of available studies in this area of interest despite of its treatment implications.[1]

The study by Peck S, Peck L, and Kataja titled "The Gingival Smile Line" investigated the factors contributing to the gingival smile line. The authors found that a high smile line is most commonly associated with vertical maxillary excess and hyperactivity of the upper lip elevator muscles along with factor like increased overjet, greater overbite, and a larger interlabial gap at rest. However, the study showed no significant correlation towards upper lip length, unlike ours.[11]

Although gender based analysis of the parameters was not incorporated in the present study, there are studies with results at par with ours. The mean upper lip length in Indian females were studied by Kalha et al and Grewal et al. It was 19.62 ±3.77 mm in the former study and ranged between 18.48-28.73mm in the latter.[12,13]

Rashed R etal studied lip tooth relationship in various malocclusions report that Class II Division 1 malocclusion exhibited the highest maxillary incisor display during smiling, while Class III subjects showed reduced tooth exposure. The authors emphasized that understanding these variations is crucial for esthetic treatment planning in orthodontics.[14] Burstone in his study has suggested that upper lip length tends to be shorter in persons with Class II, division 1 malocclusion than those with normal faces or occlusion.[15] Albeit the current study evaluates upper lip length and incisor exposure in relation to facial growth patterns, further research should be similar to the above studies that correlated lip-tooth parameters to malocclusion. This integrated assessment would enable a more comprehensive analysis, leading to a holistic and individualised treatment approach.

Despite the inherent limitations including small sample size, single centre retrospective cross sectional design and lack of gender-wise analysis, the present study could offer valuable insights through its standardized methodology and evaluation of clinically relevant esthetic parameters. By contributing region specific data, the study enhances the understanding of ethnic variations in smile esthetics.

CONCLUSION

The present study underscores the clinical relevance of upper lip length and incisor exposure in relation to facial growth patterns, highlighting their integral role in smile esthetics and reinforcing the need for its incorporation into orthodontic diagnosis and treatment. Future investigations employing larger, multicentric, prospective designs with inclusion of malocclusion and skeletal parameters, and integration of 3-D imaging and digital smile analysis are warranted to facilitate a holistic orthodontic treatment planning.

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