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Original Article

Dentistry Section

Association between Lip Prints and Skeletal Malocclusion using Digital Photography: A Cross-sectional Study

JYOTSNA SLESHA SUDHARSHAN KILLI[1], CHIRLA ANIL[2], MEHER VINEESHA CHEEPURAPALLI[3], GEETIKA SIMHADRI[4], NEERAJA PITTA[5]

ABSTRACT

Introduction: Lip prints are the lines and furrows observed on the vermilion border of human lips. Several studies have found a connection between lip prints, skeletal malocclusion and gender. Establishing a direct relationship between lip prints and sagittal jaw relationships in different genders can aid clinicians in early prediction of malocclusion types.

Aim: To identify the association between lip prints, skeletal class I and class II malocclusions in different genders using digital photographs.

Materials and Methods: An analytical cross-sectional study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics at Anil Neerukonda Institute of Dental Sciences, Vishakhapatnam, Andhra Pradesh, India. The duration of the study was two months, from June 2022 to July 2022. A total of 120, out of which 60 (30 males and 30 females) participants with Angles's class I malocclusion and 60 (30 males and 30 females) with Angle's class II malocclusion were included, based on angle formed by point A, nasion (N) and point B (ANB angle) aged between 18 to 30 years. Digital photographs were captured using an SLR digital camera. The lip print pattern in a 10 mm wide area in the middle of the lower lip was determined using Suzuki and Tsuchihashi's method. Statistical analysis was performed using the Chi-square test.

Results: The most prevalent lip pattern in skeletal class I malocclusion was the branched lip pattern (type-II) in 43.33% of 60 participants, while the intersected pattern (type-III) was most prevalent in skeletal class II malocclusion with 38.33% of 60 participants. Among males, the most prevalent lip pattern was the branched lip pattern (type-II) in 46.67% of 60 participants, while in females, the vertical groove across the lip pattern (type-I) was most prevalent in 46.67% of 60 participants. Statistical significance was observed between lip pattern, skeletal malocclusion and gender (p=0.0416 in males and p=0.01397 in females). When gender is not considered, statistically significant differences were observed between the two malocclusions in (type-II) branched lip pattern (type-II) (p=0.023) and the intersected lip pattern (type-III) (p=0.001). When skeletal malocclusion is not considered, statistically significant differences were observed between the two genders in the vertical lip pattern (type-I) (p=0.001) and the branched pattern (type-II) (p=0.04). When comparing the association of lip print pattern between skeletal class I and class II malocclusions in males and females significant differences were found between skeletal malocclusion and gender (males: p=0.008, females: p=0.004) only in (Type III) intersected lip pattern.

Conclusion: In conclusion, lip prints can serve as a useful tool in identifying skeletal malocclusion. The (type-III) intersected lip pattern shows a higher likelihood of predicting class II malocclusion compared to the type-II branched lip pattern, which is more indicative of class I malocclusion.

Keywords: Cephalometric analysis, Lip print patterns, Sagittal jaw relationship

INTRODUCTION

The study of lip prints is called cheiloscopy, derived from the Greek words "Cheilos" meaning 'lips' and "Ekopein" meaning 'to see' [1]. Lip prints are lines and furrows in the form of grooves seen in the vermilion border of human lips [2]. They remain unchanged by illnesses, accidents, or environmental factors [3]. Disruptions during embryological growth can affect the palate, alveolus and lips all grow embryologically at the same time, any incident disrupting this process can have an impact on all these structures [4]. Anthropologist Fischer, first studied lip prints in 1904 [5], and in 1950, Snyder proposed their use for identification [2]. Santos M described the use of unique lip prints for identification in 1960 Suzuki suggested methods for its use in forensic applications in 1967 [6,7]. Lip prints have been classified into six groups by Suzuki K and Tsuchihashi Y in 1970 [8,9]:

- Type I: Clear-cut groove vertically across the lips;
- Type I': Partial-length groove of type-I;
- Type II: Branched groove;
- Type III: Intersected groove;
- Type IV: Reticular pattern;
- Type V: Other lip patterns.

Lip prints can be recorded using methods like lipstick-paper-cardboard, lipstick-paper, lipstick-cellophane, dental impressions, or photography [3]. Most of the studies use lipstick to record the lip print pattern. This method has the drawback of being very time-consuming and expensive because a new lipstick needs to be used for each subject. The resultant prints could potentially be ruined by smudging [10]. In the present study, as easy alternative digital photographs offer an easy alternative to lipstick, eliminating drawbacks like time consumption and expense [11]. Using digital photographs allows easy digitalisation. The ANB angle is suggested by Reidd to measure skeletal discrepancy. An ANB angle of 0 to 4° indicates "skeletal class I," while >4° indicates "skeletal class II." A class III sagittal jaw relation has an ANB angle of 0° or negative value.

Studies shows an association between lip prints and skeletal malocclusion [3,7,12-16], as well as, gender [10,17-20]. There have been few studies evaluating the impact of gender differences on the relationship between lip prints and skeletal malocclusions, as well

as, how the relationship between lip prints and gender varies based on the type of skeletal malocclusion. Establishing a association between lip prints and sagittal jaw relationships across genders can help clinicians predict malocclusion types at an early age. Therefore, the aim of the present study was to identify associations between lip prints and skeletal class I and class II malocclusions in different genders using digital photographs. The objectives of the study are as follows:

- Identify the predominant lip print pattern in class I and class II malocclusions.
- Identify the predominant lip print pattern in males and females.
- Determine the association of lip print patterns between skeletal class I and class II malocclusions.
- Explore the association between lip print patterns and gender.
- Analyse the association of lip print patterns between skeletal class I and class II malocclusions in males and females.

MATERIALS AND METHODS

An analytical cross-sectional study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics at Anil Neerukonda Institute of Dental Sciences, Vishakhapatnam, Andhra Pradesh, India. The duration of the study was two months, from June 2022 to July 2022. Ethical clearance was obtained from the Institutional Ethical Committee (ANIDS/IEC/202206011), and informed consent was obtained from both parents and participants after explaining the study's purpose and procedures.

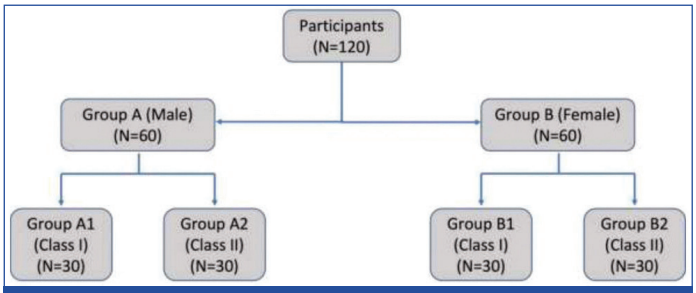
Inclusion criteria: Patients with class I or class II skeletal malocclusion, aged 18-30 years were included in the study.

Exclusion criteria: Patients with congenital facial deformities, lip lesions, lip injuries, previous orthodontic treatment, or maxillofacial surgery. Patients, who did not provide informed consent and those with class III skeletal malocclusion were excluded from the study.

Sample size calculation: Considering the effect size to be measured (d) at 0.2, power of the study power (95%), and margin of error (0.05%), the sample size was determined to be N=11 with a 6% attrition rate. Eight additional samples were added to compensate for potential sample loss, resulting in a total sample size of 120 based on G Power analysis (30 in each group).

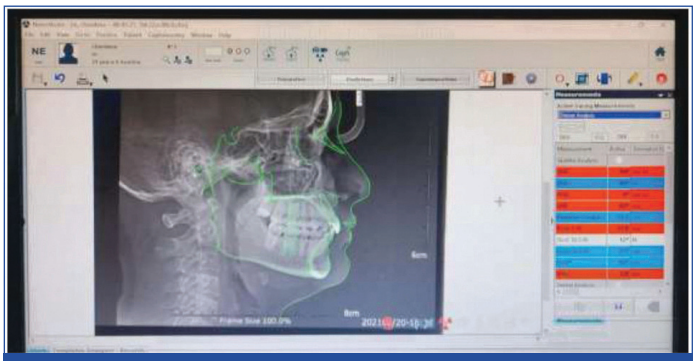
Study Procedure

Based on the ANB angle, 30 male participants and 30 female participants with Angle's class I skeletal malocclusion, as well as, 30 male and 30 female participants with Angle's class II malocclusion, were included [21]. A total of 120 subjects volunteered for the study and were divided into two groups of 60 each, based on gender (male and female). Within each group, based on skeletal malocclusion, identified using the ANB angle in lateral cephalograms, they were further subdivided into 30 each: group A1 (class I malocclusion) and Group-A2 (class II malocclusion) in Group-A (male), and Group B1 (class I malocclusion) and group B2 (class II malocclusion) in Group-B (female) [Table/Fig-1].



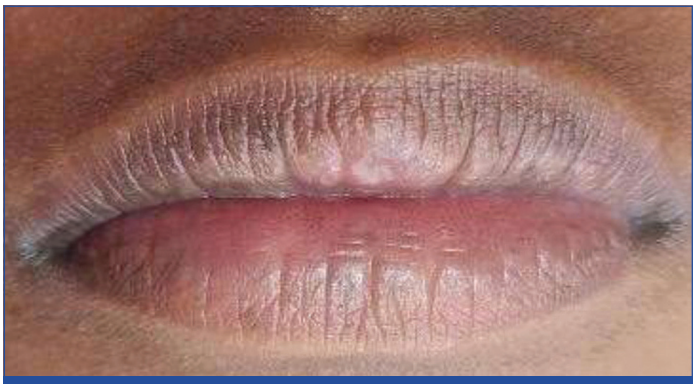
[Table/Fig-1]: Sample distribution.

Skeletal malocclusion identification: Digital cephalograms were recorded using the Villa Rotograph Evo D machine, which captures lateral cephalograms and orthopantomographs. The settings for cephalograms were 6 kV, 12 mA current and an exposure time of 0.8 sec. Images were processed using Villa Dental Studio Plus software. Nemoceph Orthodontic Cephalometric analysis software-Nemo Studio 2017 was used to analyse the 120 digital cephalograms. The ANB angle, determined through Steiner's analysis, was used to assess the skeletal relationship of each individual. The digital cephalogram is analysed for the ANB angle using Nemoceph cephalometric software [Table/Fig-2].

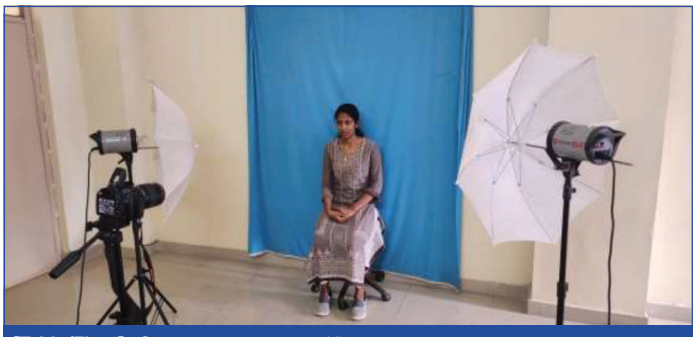


[Table/Fig-2]: Digital cephalometric analysis.

Lip print recording method: Participants were positioned in Natural Head Position (NHP) for lip photography [Table/Fig-3]. Lip photographs were taken in a natural state without lipstick or lip gloss, using an SLR digital camera mounted on a tripod stand [Table/Fig-4]. Each participants was photographed twice, and the best image was selected for the study.



[Table/Fig-3]: Digital photograph of lip.



[Table/Fig-4]: Camera setup to record lip.

Assessment of lip prints: A 10 mm wide area in the middle part of the lower lip was chosen as the study area for lip pattern classification [22]. This area was selected due to its consistent visibility and the higher occurrence of lines in this region [23]. Lip patterns were classified by counting the highest number of lines in this area, following the classification system of Suzuki K and Tsuchihashi Y [8]. Each digital photograph was assessed three times to identify the lip pattern and the pattern that appeared most frequently was documented. Multiple assessments were conducted to minimise errors in differentiating between lip patterns.

STATISTICAL ANALYSIS

The obtained data were tabulated and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) version 25.0. The frequency distribution of lip print types seen in skeletal class I and class II malocclusion, categorised by gender, was recorded. A Chi-square test with a significance level of p<0.05 was used to determine the statistical significance of the association between lip print and skeletal malocclusion, as well as, the differences influenced by gender.

RESULTS

The results of the study showed that, the most prevalent lip pattern was type-II (branched lip pattern) at 31.7%, followed by type-I (vertical groove across the lip) at 30%, type-III (intersected pattern) at 21.7%, type-IV (reticular pattern) at 10%, and type-I (partial groove pattern) at 6.7% [Table/Fig-5]. These differences were found to be statistically significant (p=0.0004).

Lip pattern	Class I macocclusion				Class II malocclusion				Total n (%)	p-value
	A1 (30) male	B1 (30) female	Total n (%)	p-value	A2 (30) male	B2 (30) female	Total n (%)	p-value		
I	5	16	21 (35)	0.0414*	3	12	15 (25)	0.0291*	36 (30)	0.0004*
I'	2	2	4 (6.7)		2	2	4 (6.7)		8 (6.7)	
II	18	8	26 (43.3)		10	2	12 (20)		38 (31.7)	
III	2	1	3 (5)		12	11	23 (38.3)		26 (21.7)	
IV	3	3	6 (10)		3	3	6 (10)		12 (10)	
V	0	0	0		0	0	0		0	

[Table/Fig-5]: Overall predominant lip pattern and predominant lip pattern in class I and class II malocclusion.
*Chi-square test p<0.05 Significant

In the skeletal class I group, the most prevalent lip pattern was type-II at 43.33%, followed by type-I at 35%, with a statistically significant difference (p=0.0414) [Table/Fig-5]. In the skeletal class II group, the most prevalent lip pattern was type-III at 38.33%, followed by type-I at 25% [Table/Fig-5,6]. The difference between these patterns was statistically significant (p=0.0291) [Table/Fig-5].

Lip pattern	Class I (n=60) n (%)	Class II (n=60) n (%)	p-value	p-value
I	21 (35)	15 (25)	0.317	0.000247*
I'	4 (6.67)	4 (6.67)	1.00	
II	26 (43.33)	12 (20)	0.023*	
III	3 (5)	23 (38.33)	0.001*	
IV	6 (10)	6 (10)	1.00	
V	0	0	0	

[Table/Fig-6]: Association of lip print pattern between skeletal Class I and Class II malocclusion.
*Chi-square test p<0.05 significant

Statistical analysis revealed a significant association between lip pattern type and skeletal malocclusion (p=0.000247) [Table/Fig-6]. When gender was not considered, statistically significant differences were observed between the two malocclusions for type-II (branched lip pattern) (p=0.023) and type-III (intersected pattern) (p=0.001) [Table/Fig-6]. Among males, the most prevalent lip pattern was type-II at 46.67%, followed by type-III at 23.33% [Table/Fig-7,8]. This difference was found to be statistically significant (p=0.0416) [Table/Fig-8]. There was also statistical significance observed between lip pattern type and gender (p=0.000549). When skeletal malocclusion was not considered, statistically significant differences were found between the two genders for type-I (vertical lip pattern) (p=0.001) and type-II (branched pattern) (p=0.004) [Table/Fig-7].

Lip pattern	Males (n=60) n (%)	Females (n=60) n (%)	p-value	p-value
I	8 (13.33)	28 (46.67)	0.001*	0.000549*
I'	4 (6.67)	4 (6.67)	1.00	
II	28 (46.67)	10 (16.67)	0.004*	
III	14 (23.33)	12 (20)	0.695	
IV	6 (10)	3 (5)	1.00	
V	0	0	0.001	

[Table/Fig-7]: Association of lip print pattern and gender.
*Chi-square test p<0.05 significant

In females, the most prevalent lip pattern was type-I (vertical groove across the lip) at 46.67%, followed by type-III (intersected pattern) at 20% [Table/Fig-7,9]. This difference was statistically significant (p=0.013967) [Table/Fig-9]. There was a statistically significant association observed between type-III (reticular lip pattern) and skeletal malocclusion in males (p=0.008), while type-I (vertical), type-I (partial groove pattern), type-II (branched), type-IV (reticular), and type-V (undetermined pattern) showed no statistical difference [Table/Fig-8]. Similarly, a statistically significant association was observed between type-III (intersected lip pattern) and skeletal malocclusion in females (p=0.004), while type-I (vertical), type-I (partial groove pattern), type-II (branched), type-IV (reticular), and type-V (undetermined pattern) showed no statistical difference [Table/Fig-9].

Lip pattern	A1 (30) male	Class I (%)	A2 (30) male	Class II (%)	p-value	Total n (%)	p-value
I	5	16.67	3	10	0.48	8 (13.3)	0.0416*
I'	2	6.67	2	6.67	1.00	4 (6.7)	
II	18	60	10	33.33	0.131	28 (46.7)	
III	2	6.67	12	40	0.008*	14 (23.3)	
IV	3	10	3	10	0.001	6 (10)	
V	0	0	0	0	0.001	0	

[Table/Fig-8]: Predominant lip pattern in males and association of lip print pattern between skeletal class I and class II malocclusions in males.
*Chi-square test p<0.05 significant

Lip pattern	B1 (30) female	Class I (%)	B2 (30) female	Class II (%)	p-value	Total n (%)	p-value
I	16	53.33	12	40	0.45	28 (46.7)	0.01397*
I'	2	6.67	2	6.67	1.00	4 (6.7)	
II	8	26.67	2	6.67	0.58	10 (16.7)	
III	1	3.33	11	36.67	0.004*	12 (20)	
IV	3	10	3	10	1.00	6 (10)	
V	0	0	0	0	0.001	0	

[Table/Fig-9]: Predominant lip pattern in females and association of lip print pattern between skeletal class I and class II in females.
*Chi-square test p<0.05 significant

DISCUSSION

Lip prints are unique to each individual and established before skeletal and dental jaw relation. If a significant positive association is found between lip prints and skeletal malocclusion, it can be used as a tool to predict skeletal malocclusion. The present study aimed to identify whether the positive correlation found between lip prints and skeletal malocclusion is similar or differs based on the gender of the individual. Several methods are available for recording lip prints. In the present study, authors used the digital photography method

suggested by Poudel P et al., [11]. The middle part of the lower lip (10 mm wide), as suggested by Sivapathasundharam B et al., was used to classify the lip print [22]. Narmatha V Jayabal, suggested that, this part of the lip is almost always visible in any trace [23].

In the present study, it was observed that, the branched lip pattern (type-II) was most prevalent among the overall subjects. Similar results were reported in studies conducted by Sonal V et al., Poudel P et al., Raghav P et al., Kaushal B et al., Timsinha S and Kar SM, and Ravindra V et al., in the North Indian population [5,11,12,15,24,25]. According to studies conducted by Aditi S et al., Poudel P et al., and Randhawa K et al., in the North Indian population, Vahanwala SP and Parekh BK in the Mumbai population, Ragab AR et al., in the Egyptian population, Sandhu SV et al., in the Punjab population, Ize-Iyamu IN and Aghimien OA, in the Nigerian population, Uma Maheswari TN and Venugopal A [3,11,19,26-30], the vertical groove lip pattern (type-I) is the most prevalent. In studies done by Sivapathasundharam B et al., in the Indo-Dravidian population and Tsuchihashi Y, in the Japanese population found the intersected pattern (type-III) to be the most prevalent [22,31]. Badiye A and Kapoor N in the central Indian population, Verghese AJ et al., in the Kerala population and Verghese AJ et al., in the Karnataka population found that, the reticular pattern (type-IV) had the highest incidence [10,32,33]. Prabhu RV et al., in Goan population found the undetermined lip pattern (type-V) to be the most predominant [34]. The difference in prevalence observed in different studies indicates that lip patterns shows regional variation [Table/Fig-10] [4,5,10,12,15,19,24,26-29,31-34].

Previous studies	Sample size	Population	Type of lip print pattern which was found predominant
Sonal V et al., [5] (2005)	50	North Indian	Branched lip pattern (type-II)
Raghav P et al., [12] (2013)	114	North Indian	Branched lip pattern (type-II)
Kaushal B et al., [15] (2018)	90	North Indian	Branched lip pattern (type-II)
Timsinha S et al., [24] (2019)	100	North Indian	Branched lip pattern (type-II)
Vignesh R et al., [4] (2019)	300	North Indian	Branched lip pattern (type-II)
Vahanwala SP and Parekh BK [26] (2000)	100	Mumbai	Vertical groove lip pattern (type-I)
Randhawa K et al., [19] (2011)	600	North Indian	Vertical groove lip pattern (type-I)
Ragab AR et al., [27] (2013)	955	Egyptian	Vertical groove lip pattern (type-I)
Sandhu SV et al., [28] (2012)	106	Punjabi	Vertical groove lip pattern (type-I)
Ize-Iyamu IN and Aghimien OA [29] (2017)	170	Nigerian	Vertical groove lip pattern (type-I)
Tsuchihashi Y [31] (1974)	1364	Japanese	Intersected pattern (type-III)
Verghese AJ et al., [32] (2010)	100	Kerala	Reticular pattern (type-IV)
Verghese AJ et al., [33] (2011)	200	Karnataka	Reticular pattern (type-IV)
Badiye A and Kapoor N [10] (2016)	400	Central Indian	Reticular pattern (type-IV)
Prabhu RV et al., [34]	100	Goan	Undetermined lip pattern (type-V)

[Table/Fig-10]: Prevalence of lip print patterns in various regions [4,5,10,12,15,19,24,26,27,28,29,31,32,33,34].

When considering only subjects with class I malocclusion, the branched lip pattern (type-II) was most prevalent, similar to the overall subjects. When considering only subjects with class II malocclusion, the intersected pattern (type-III) was most prevalent. The variation of lip prints with skeletal malocclusion can be considered positive, as the association between lip prints and skeletal class I and class II malocclusion was found to be statistically significant. This indicates that, the presence of type-II (branched lip pattern) and type-III (intersected lip pattern) can be used to predict class I and class II malocclusion, respectively, to a certain degree. Similar results were reported by Aditi S et al., where type-III (intersected pattern) was most prevalent in class II malocclusion and Ponnusamy S et al., reported type-II (branched lip pattern) was most prevalent in class I malocclusion [3,14].

Contrary to the present study, studies conducted by Aditi S et al., and Vignesh R et al., showed type-I (vertical groove lip pattern) was more predominant in class I malocclusion and in subjects with Class-II malocclusion, studies by Vignesh R et al., showed Type-IV (reticular pattern) [3,4]. Ponnusamy S et al., showed type-I (vertical groove lip pattern) to be the most predominant [14]. In males, the branched lip pattern (type-II) was most prevalent, whereas, in females, the vertical groove lip pattern (type-I) was more prevalent. Similar results were reported by Badiye A and Kapoor N, Poudel P et al., Bajracharya D et al., and Jatti D and Rastogi P where type-II (branched lip pattern) was prevalent in males [10,11,17,20]. Studies conducted by Poudel P et al., Bajracharya D et al., Sharma P et al., Randhawa K et al., Vahanwala SP and Parekh BK, Babu NC et al., Malik R and Goel S, Dwivedi N et al., and Baral R et al., showed that, type-I (vertical groove lip pattern) was prevalent in females [11,17-19,26,35-38]. The difference between the type-II (branched lip pattern) seen in males and the type-I (vertical groove lip pattern) seen in females in the present study was statistically significant. Therefore, the variation of lip prints with gender can be considered positive.

Contrary to the present study, studies conducted by Randhawa K et al., Vahanwala SP and Parekh BK, Dwivedi N et al., Babu NC et al., and Baral R et al., showed type-III (intersected pattern) to be the predominant lip pattern, and Malik R and Goel S showed type-IV (reticular lip pattern) to be the predominant lip pattern in males [19, 26, 35-38]. In females, Badiye A and Kapoor N showed type-IV (reticular lip pattern) to be predominant [10]. All these studies indicate that, there is a difference in lip pattern between males and females, which can be used to determine the gender of the individual. Studies by Ponnusamy S et al., Ragab AR et al., Sandhu SV et al., Verghese AJ et al., and Nagasupriya A et al., showed no differences in lip patterns between males and females [14,27,28,32,39]. When the association of lip prints with malocclusion in males and females is evaluated separately in the present study, it was found that, only the (type-III) intersected lip patterns showed statistically significant variation in lip print due to malocclusion. This shows the predominance of skeletal malocclusion over gender and the predictability percentage of (type-III) intersected lip pattern in predicting class II malocclusion. Based on these results, cheiloscopy can be used in clinical practice, and malocclusion can be predicted at an early age, allowing for preventive and interceptive orthodontic procedures to prevent full-blown malocclusions.

Limitation(s)

Cheiloscopy can only predict malocclusion caused by genetic factors. Local and environmental factors play a significant role in causing malocclusion. This is a major limitation in the use of cheiloscopy for predicting malocclusion. A larger sample size of participants with different regional and racial backgrounds, as well as, a multicentric study, will reveal a more precise association of the various parameters used in the present study. Class III malocclusion is not considered.

CONCLUSION(S)

It can be concluded that, lip prints can be used to identify skeletal malocclusion. The (type-III) intersected lip pattern has a higher probability of predicting class II malocclusion compared to the (type-II) branched lip pattern, which is more suitable for predicting

class I malocclusion. The (type-II) branched lip pattern and the (type-I) vertical lip pattern can be used to identify the gender of the individual (male and female, respectively). The (type-III) intersected lip pattern has a higher probability of predicting class II malocclusion than the (type-II) branched lip pattern for predicting class I malocclusion.

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PARTICULARS OF CONTRIBUTORS:
1. Undergraduate, Department of Orthodontics and Dentofacial Orthopaedics, Anil Neerukonda Institute of Dental Sciences, Visakhapatnam, Andhra Pradesh, India.
2. Professor, Department of Orthodontics and Dentofacial Orthopaedics, Anil Neerukonda Institute of Dental Sciences, Visakhapatnam, Andhra Pradesh, India.
3. Reader, Department of Orthodontics and Dentofacial Orthopaedics, Anil Neerukonda Institute of Dental Sciences, Visakhapatnam, Andhra Pradesh, India.
4. Senior Lecturer, Department of Orthodontics and Dentofacial Orthopaedics, Anil Neerukonda Institute of Dental Sciences, Visakhapatnam, Andhra Pradesh, India.
5. Senior Lecturer, Department of Orthodontics and Dentofacial Orthopaedics, Anil Neerukonda Institute of Dental Sciences, Visakhapatnam, Andhra Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Chirla Anil,
50-104-3, N.E. Layout, Seethemmadhara,
Visakhapatnam-530013, Andhra Pradesh, India.
E-mail: anilchirla@gmail.com

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