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Original Research Article

Relationship of skeletal malocclusion classification and sagittal lip position in children

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ABSTRACT

Malocclusion diagnosis can be established through history taking, clinical examination, and evaluation of diagnostic records in the form of study models, clinical photographs, and cephalometric radiographs. Cephalometric radiograph is an important data for evaluating the craniofaciodental relationship and for assessing the soft tissue matrix. The purposes of this study were to describe the position of the sagittal lip based on Jefferson's class I, II, and III classification of skeletal malocclusions, as well as, to see the relationship between the skeletal classification and the position of the sagittal lip in children.

The research method used was analytic cross-sectional, consisting of 90 secondary data of pediatric patients (age 8-12 years) at RSGM, Padjadjaran University, Bandung. This study used Jefferson's analysis to determine the skeletal classification and Sushner's analysis to determine the position of the sagittal lips. The data then were analyzed using Kendall Concordal analysis and Spearman Rank correlation.

The results showed that the sagittal lip position in the three skeletal malocclusions was more protrusive than the normative value. There was a statistically significant relationship between the skeletal malocclusion class and the position of the upper and lower lip (at 80%, p-value = 5.69E-32 <0.05).

The conclusion of this study is there is a relationship between the classification of skeletal malocclusion classes I, II, and III and the sagittal lip position in children.

1. Introduction

Malocclusion is the third most common oral health problem after dental caries and periodontal disease according to the World Health Organization (WHO).[1] Malocclusion is a deviation from ideal occlusion that is considered aesthetically or functionally unsatisfactory and can occur due to genetic, environmental, or a combination of both factors in the developmental pathway involved in the formation of the orofacial region.[2–4] Malocclusion can be corrected by orthodontic treatment, involving a complete history taking, thorough clinical examination, and collection of appropriate diagnostic records, such as study models, clinical photographs, and cephalometric radiographs.[3–5] A study model is not able to show and provide important information about skeletal relationships in a patient, therefore an analysis of cephalometric radiographs is necessary in the process of making a diagnosis and treatment planning.[6]

Jefferson cephalometric analysis is a non-numerical analysis that is simple, easy to understand, practical, universal, and not influenced by race.[7] This analysis evaluates the lateral profile of facial hard tissues to determine a diagnosis and treatment plan by considering the aesthetic and functional aspects of facial appearance, temporomandibular joint health, as well as the psychological health of a patient.[7] Soft tissue analysis

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as an integral part of diagnosis and treatment planning has also been developed to assist clinicians in quantitatively evaluating facial morphology which involves the nose, lips, and chin. Lip position has been one of the most important soft tissue analyses as it affects occlusion, tooth stability, and facial aesthetics.[3,8]

Study regarding Sushner's S2 reference line is still rarely done. In previous studies, Joshi[8] stated that the sagittal lip position is associated with skeletal malocclusion patterns in the Chinese population aged 18-25 years. The sagittal position of the upper lip in different skeletal malocclusions in the study can be assessed better with the Sushner's S2 line because this line passes through stable and consistent anatomical landmarks as it is adjacent to the skeletal structure and not influenced by the nose.[9] Similar study[10] was also conducted in Indian population aged 18-26 years.

Jefferson analysis and sagittal lip position analysis are cephalometric analyses that have not been studied further and published scientifically in the children population in Indonesia. Therefore, researchers are interested in analyzing the relationship between the classification of skeletal malocclusion and sagittal lip position in children. The results of the study are expected to provide information for determining the diagnosis and planning of interceptive orthodontic treatment, especially for children in Indonesia.

2. Materials and Methods

The study population was the cephalometric radiograph results of pediatric patients aged 8-12 years who came to the Pediatric Dentistry Polyclinic in Dental Hospital of Padjadjaran University (RSGM UNPAD) from 2018 to 2021 and had been diagnosed with class I, II, and III skeletal malocclusions.

The subjects used in this study were cephalometric radiographs of pediatric patients aged 8-12 years old who came to the Pediatric Dentistry Polyclinic in Dental Hospital of Padjadjaran University (RSGM UNPAD), Bandung. The objects observed in this study were secondary data in the form of digital cephalometric radiograph results of the research subjects.

The research sample was selected using purposive sampling technique, according to the inclusion criteria as follows:

1. Digital cephalometric radiographs of non-syndromic patients manifesting in hard and soft tissue abnormalities in the craniofacial region.
2. Lateral cephalometric radiographs of pediatric patients aged 8-12 years old.
3. The result of cephalometric radiographs has good quality, detail, contrast, and density.

The criteria excluded in this study were patients who were currently undergoing or have had orthodontic treatment.

This research had obtained an ethical approval from the Ethical Committee of Padjadjaran University with reference number 253/UN6.KEP/EC/2022. The research was conducted at the Pediatric Dentistry Installation of RSGM UNPAD from March to May 2022 and had obtained a research approval number 789/UN6.RSGM/TU.00.

Materials and tools used in this research were lateral cephalometric radiographs, a 14" laptop, Microsoft Office 365 Software (Word, Excel, PowerPoint), and IC Measure application.

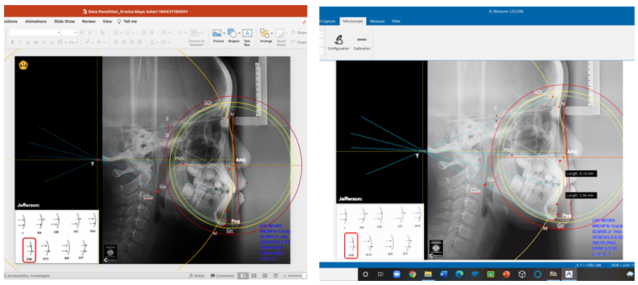

Fig. 1: Jefferson analysis technique and measurement of sagittal lip position

3. Results

According to the inclusion and exclusion criteria, 90 data samples of cephalometric radiographs were obtained. The characteristics of the sample based on gender and age were shown in Table 1. The majority of patients were 9 years old found in 25 cephalometric radiograph samples (27.78%), while the minority of patients was 8 years old found in 6 cephalometric radiographs (6.67%). Skeletal class I was the largest classification found in a total of 30 samples (33.33%), followed by class II B with 26 samples (28.89%) and class III A with 18 samples (20%).

Table 2 showed the description of lip positions in Class I, II, and III malocclusions. The results showed that the lip positions were more protrusive in class I malocclusion compared to Sushner's normative value in male and female subjects. Table 2 also described more protrusive lip positions in class II malocclusion compared to Sushner's normative value as well as class I, II, and III malocclusions. The results also showed that the upper and lower lip positions in class III malocclusion were more protrusive than Sushner's normative value but more retrusive than the lip positions in class I and II malocclusions.

The relationship or correlation between the classification of malocclusion with the upper and lower lip positions was analyzed using a non-parametric test in the form of Kendall's Coefficient of Concordance (W). The result showed W value = 0, 80 which was statistically significant with p-$value$ = 5, 69E-32 = 0,00....00569 < 0,05. This implied that there was a relationship between the malocclusion classes with the upper and lower lip positions

Table 1: Characteristics of samples according to gender, age, and Jefferson's classification

	Number of Samples	%
Gender		
Male	36	40
Female	54	60
Age (years)		
8	6	6,67
9	25	27,78
10	20	22,22
11	20	22,22
12	19	21,11
Jefferson's Classification		
Class I	30	33,33
Class II A	4	4,44
Class II B	26	28,89
Class II C	0	0
Class III A	18	20
Class III B	12	13,33
Class III C	0	0
Total	**90**	**100,00**

Table 2: Description of upper and lower lip positions in class I, II dan III malocclusion

Malocclusion	Gender	n	UL (mm)		LL (mm)	
			Mean	std	Mean	std
Class I	M	14	11,4	2,5	8,2	2,5
	F	16	10,8	0,3	5,6	0,6
	M+F	30	11,1	2,2	7,9	2,4
Class II	M	11	15,7	3,3	12,7	4,3
	F	19	11,9	0,1	7,6	0,5
	M+F	30	12,1	2,6	11,8	5,5
Class III	11	9,8	0,2	7,1	0,5	0,5
	19	10,5	3,3	9,1	4,4	4,4
	30	11,3	3,0	9,8	3,3	3,3

Notes: M= male, F= female, N= number of samples, UL= measurement of upper lip position, LL= measurement of lower lip position, std= standard deviation

of 80%. The partial correlation of malocclusion with each lip was calculated using Spearman Rank Correlation analysis as shown in Table 3.

Table 3 showed a correlation of 19,01% between malocclusion and the upper lip distance which was statistically significant, but the correlation between malocclusion and the lower lip distance was only 2,16% which was statistically insignificant (*p-value* = 0,08339 > 0,05). If the correlation between the upper and lower lips was calculated as well, it gave a statistically significant result of 57, 46%.

The hypothesis was analyzed using a *t*-test, where a significant level of 95% was determined and the criteria for H_0 rejection was of *p-value* <0, 05. Statistical analysis was performed using the *Statistical Package Excel MegaStat*. The result showed that there was a relationship between the class I, II, and III of skeletal malocclusion classification and the sagittal lip positions.

4. Discussion

Malocclusion treatment or interceptive orthodontic treatment should be carried out as early as possible in their growth and development period when signs and symptoms of malocclusion begin to occur.[11] This treatment aims to improve jaw relations, prevent malocclusion from developing further, improve facial profile to increase self-confidence, eliminate bad habits, facilitate the normal eruption of teeth and improve growth patterns.[12,13]

Many recent studies discussed the relationship between the morphology of soft tissue of the nose and chin with the dentoskeletal pattern, but there are still few studies discussing the correlation between malocclusion and lips.[14–16] This study can measure the sagittal lip positions of the three different classes of malocclusion. Sushner's line was selected as the reference line, with the reference point adjacent to the skeletal structure, and not influenced by the nose so that the lip position was able to be assessed better.[8,10] Pandey et al. described in their research that

Table 3: Relationship between the classification of malocclusion with upper and lower lip positions

Variable	r_s	t	p-value	Characteristics	Correlation
MO & UL	-0,44	-4,54	8,718E-06	Sign	19,01
MO & LL	-0,15	-1,39	8,339E-02	Non-Sign	2,16
LL & UL	0,76	10,90	2,588E-18	Sign	57,46

Notes: MO= Malocclusion, UL= Upper Lip, LL= Lower Lip

the Sushner's line passes through a stable and consistent anatomical landmark to evaluate sagittal lip position on the profile analysis and has been reported in several previous studies in different populations as well.[9]

Selection of the age range for the research subjects, which was 8-12 years, was based on the estimation of the complete eruption of the four upper and lower permanent anterior teeth as well as the upper and lower permanent first molar so that the cephalometric line could be determined to evaluate the anteroposterior relationship of the maxilla and mandible position. The age selection was also based on the estimated age of the child's mixed dentition period. Mixed dentition is a period that can potentially cause malocclusion and is the ideal time to carry out growth modification.[11,17] Age 8-12 years is the time when children begin to understand their physical condition, including their malocclusion condition, which can affect their social relationship with their friends. A study by Narayanan in 2016 also reported that there was an increased prevalence of malocclusion in the age group of 10-12 years.[18] Based on the results of previous studies, it was suggested that malocclusion in 8-12-year-old children needs to be studied further.

Research subjects used in this study were the results of lateral cephalometric radiographs of pediatric patients aged 8-12 years which were taken for diagnostic purposes. The secondary data of cephalometric radiographs were used as research objects because this type of radiograph is an appropriate source of information for evaluating the craniofaciodental relationship and assessing the soft tissue matrix, one of which is the position of the lips. Radiographic results can be used as a basis or complementary data to analyze the skeletodental relationship before, during, and after treatment.[4,19]

The secondary data taken was the result of digital lateral cephalometric radiograph which provides several advantages and conveniences, including a much faster radiograph processing and the ability to adjust the contrast level of the image result. These advantages are considered important since they can reduce the possibility of retaking the radiograph as well as reduce the risk of errors when tracing and analysis were conducted.[20]

The use of soft tissue norms in one population cannot be set as a reference in diagnosis and treatment planning for other populations.[8–10,21] The Sushner norm was developed in the black population, while the Ricketts norm was applied to Caucasians and not to all groups of ethnicity and race.[8,10] This study assessed the sagittal lip position using the Sushner reference line in the children population in Indonesia, which can be used as the baseline data for malocclusion diagnosis and treatment planning.

The result of this study showed that lip positions in the majority of male subjects were more protruded than in female subjects (Table 2). This may be related to an increase in upper lip thickness in males compared to females. The effect of testosterone in facilitating the synthesis of collagen can cause males to have thicker soft tissues, meanwhile, the estrogen in females facilitates the synthesis of hyaluronic acid which can cause a decrease in collagen synthesis so that females may have thinner soft tissues.[22] This was in agreement with a study conducted by Uysal[21] which stated that gender difference significantly affects the thickness of labrale superius, labrale inferius, pogonion, and menton measurement.

The increase in length of the upper and lower lips in males was twice as large as in females, similar to the studies by Arnett, Kalha, Lalitha, Hamdan, and Yan, et al.[9,23–25] A study of soft-tissue growth in 7-18-year-old subjects conducted by Nanda reported that the length of upper lip measured from subnasal to stomion increased up to 2.7 mm in males and 1.15 mm in females. Meanwhile, the height of lower lip (measured from stomion of the lower lip to the B point of soft tissue) increased up to 4.2 mm in males and 1.5 mm in females.[26]

The sagittal skeletal pattern indicates the anteroposterior displacement of maxilla and mandible. Skeletal class I pattern showed that the upper and lower jaws are in a relatively harmonious position.[25] Results (Table 2) described that the upper and lower lip positions in Jefferson's class I skeletal malocclusion in pediatric patients were more protrusive than the normative value. This was in line with a study by Joshi et al. which stated that subjects with class I skeletal malocclusion in the Chinese population have more protruded upper and lower lip positions compared to the reference line.[8] The present study can be related to the previous studies which explained that the facial profile of Javanese who belongs to the Deutro-Malay race has a convex nose, lips, and chin proportion.[27] Based on other studies regarding facial profiles in Indonesia, both the skeletal and soft-tissue profiles of Indonesians were generally more convex. This convexity of the facial profile of Indonesians may be caused by several factors, such as midfacial retrusion, maxillary protrusion, a more protrusive inclination of anterior teeth, and chin recession. This further

supports the result of our study which described the majority of protrusive lip profiles as the sampling was done in West Java and the majority of patients who came to RSGM UNPAD were Deutro-Malays.[28–30]

Skeletal class II malocclusion indicates that the upper jaw is relatively more prognathic than the lower jaw.[25] There are three possible etiology of skeletal class II malocclusion, i.e. maxilla growth to the cranium is prognathic, but the mandible growth to the anterior is normal; maxilla growth to the cranium is normal, but the mandible growth to the anterior is retrognathic; maxilla growth to the cranium is prognathic and the mandible growth to the anterior is retrognathic.[31]

Table 1 presented the sample characteristics according to the results of Jefferson's analysis. Of 30 samples with Jefferson's skeletal class II malocclusion, 4 samples were of class II A (13,32%) and 26 samples were of class II B (86,67%). The sample in this study was similar to Gusti's study on the Javanese, which found that skeletal class II malocclusion was caused by a micrognathic mandible.[32] Another study conducted by McNamara[33] in patients aged 8-10 years old stated that skeletal class II malocclusion was caused by a retrognathic mandible (75%).

The description of upper and lower lip positions in Jefferson's classification of skeletal class II malocclusion (Table 2) was more protrusive than the normative value and the most protrusive compared to skeletal class I and III malocclusions. This result was in line with the study by Murthy[10] on subjects aged 18-26 years in India, as well as the study by Godt et al. and Joshi et al. which stated that class II malocclusion had been proven to be associated with a more anterior upper lip position.[8,34]

The majority of class III samples were of class III A (Table 2), which indicated a retrognathic growth of the maxilla while the mandible growth was normal. The samples were in line with the previous findings where it was stated that two-thirds of the skeletal class III malocclusion cases were caused by maxilla retrognathism or a combination of both maxilla retrognathism and mandible prognathism.[13]

The description of upper lip position in Jefferson's skeletal class III malocclusion in pediatric patients was the most retrusive compared to the skeletal class I and II malocclusions (Table 2). This result was in line with the research of Godt, et al. which reported that there was a decrease in overjet with a more concave profile in the skeletal class III group compared to the control group.[34]

The results in Table 2 showed the description of the average distance of the upper lip position which was greater than the lower lip position to the reference line in class III malocclusion. It was assumed to have occurred due to the Javanese Deutro-Malay ethnic background which originally came from the Mongoloids who were more protrusive than the Caucasians,[35] thus it can affect the position of the Sushner line. The reference point position is also associated with various thicknesses of soft tissue (chin), as well as the underlying mandibular skeleton. Other factors that can affect the variability of soft tissue morphology in thickness, length, and tone, are genetic and environmental factors.[25,36,37]

One of the genetic factors that can affect craniofacial development, including the formation of lips during the embryonic period, was the Fibroblast Growth Factor (FGF) gene. When extracellular FGF ligands bind to FGF receptors on target cell membranes, intracellular FGF signaling can mediate a variety of different biological processes, i.e. proliferation, differentiation, and cell mobility during development.[38]

The soft tissue growth subsequently occurs with a combination of hyperplasia and hypertrophy. This process happens at all points in the tissue, known as interstitial growth, which has two characteristics, i.e. primary hyperplasia and secondary hypertrophy. Interstitial growth is the characteristic of almost all soft tissues as well as non-calcified cartilages in the skeletal system.[39]

Race is an important genetic factor that can affect the soft-tissue response to skeletal patterns.[40] A research by Wong, et al. described that there was a big difference between Caucasians' and Asians' lips, especially in females. The lower lip thickness in Chinese women was greater than in Koreans and Caucasians.[41]

Facial soft-tissue thickness is also affected by gender, age, and nutritional status.[15,42] Several studies have discussed the association between age and soft tissues, increase in upper and lower lip thickness as measured from the labial surface of incisors to the most prominent part of upper and lower lips, which was visible from childhood to adolescence.[15,26] A study by Jankowska[15] stated that dorsum axis, length, and depth of the nose also increased with age, but the nasolabial angle, nasomental angle, and the convexity of soft tissues decreased with age. Changes in facial convexity occur due to the increase in mandible growth to the anterior until the growth and changes in soft tissue thickness in the philtrum and chin area are completed.[26,43,44]

According to the study by Abdulal,[15] chin thickness and upper lip height have greater values in the hyperdivergent group. These can occur because, in a hyperdivergent facial pattern, the upper lip compensates an open bite for lip closure. This can cause a greater accumulation of lip tissues which subsequently increases its thickness.[37,45]

Basheer et al. and Inada et al.[46,47] stated that children who have mouth-breathing habit showed negative lip seal with protrusive lip, maxillary incisors proclination, and convex facial profile. Facial soft tissue dysfunction caused facial bone deformities and vice versa.[47]

Tooth characteristics, such as crowding, occlusal relationship, and incisor position also affect soft tissue

thickness.[25] A research by El Asmar et al.[36] and McNamara[48] stated that the anteroposterior position of maxillary incisors was related to upper lip thickness. Joshi et al. similarly stated that dental factors, such as the inclination of upper and lower anterior teeth, could affect lip position.[8]

The relationship between malocclusion and the distance of upper and lower lips was of 80% which was statistically significant with p-value = 5,69E-32 = 0,00....00569 < 0,05. This indicated that there was a relationship between malocclusion and the distance between upper and lower lips of 80%, which was in line with the previous studies showing that the soft and hard tissues were highly correlated.[8] The anteroposterior position of lips depends on the underlying skeletal structure, unlike the other facial soft tissues structure that did not depend on the hard tissues. Subtelny stated that lips always try to maintain their constant relationship with the alveolar process.[26]

The partial relationship between malocclusion and each lip was measured using the Spearman Rank Correlation analysis as shown in Table 4.6. Malocclusion and the upper lip distance had a correlation of 19,01% which was statistically significant, but the correlation between malocclusion and the lower lip distance was only of 2,16% which was statistically insignificant (p-value = 0,08339 > 0,05). If the correlation of upper and lower lips was also measured, it showed a statistically significant result of 57, 46%.

Diagnosis and treatment plans are the keys to orthodontic treatment.[26] Knowledge of soft tissues in the nose, lips, and chin regions is very well-considered to determine an appropriate diagnosis and treatment plan.[10,21,49] The nose, lips, and chin relationship is an essential esthetics criteria and becoming a priority in a treatment plan to obtain an optimal result.[26] Lip position is one of the most important soft tissues analysis as it can affect occlusion, tooth stability, and facial esthetics.[50]

Assessment of the sagittal lip positions referring to the Sushner reference line can serve as initial information for Jefferson's analysis of skeletal classification and is relevant to be applied to the cephalometric radiographs of children in Indonesia. The determination of skeletal classification based on the morphology of individual reference points can be interpreted well and has a relationship with the sagittal lip position as assessed by the Sushner reference line. This concludes that Jefferson's analysis as well as Sushner's analysis may become one of the essential standards that should be carried out by a dentist in determining a diagnosis and treatment plan.

This study has some limitations, as the sample used was still limited, and the methods were only limited to one reference line. This study cannot yet be used as a reference for the Deutro-Malay race, as it should have represented several ethnic groups that belong to the Deutro-Malay race group. This study has provided information about the relationship between sagittal lip position and skeletal malocclusion, however, there are other aspects that can be further studied to be able to provide a more detailed description of the overall relationship between dental, skeletal, and soft tissue conditions. The study of craniofacial growth and development, especially in children in Indonesia, is expected to be able to complement the quantitative data which eventually can create a cephalometric radiographic standard (norms) specifically for the population in Indonesia.

5. Conclusions

1. The description of the sagittal lip positions in Jefferson's skeletal class I malocclusion in pediatric patients was more protrusive than the normative value.
2. Description of the upper and lower lip positions in Jefferson's skeletal class II malocclusion was more protrusive than the normative value and the most protrusive compared to skeletal class I and III malocclusions.
3. The description of the upper lip positions in Jefferson's skeletal class III malocclusion in pediatric patients was the most retrusive compared to skeletal class I and II malocclusions.
4. There was a relationship between the skeletal class I, II, and III malocclusions with sagittal lip positions in children.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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