Pesquisa Brasileira em Odontopediatria e Clínica Integrada

ISSN: 1519-0501

apesb@terra.com.br

Universidade Estadual da Paraíba

Brasil

Barbosa, Diana; Bernal, Lucia V.; Zapata, Oscar; Agudelo-Suárez, Andrés A.; Angel, Laura; Estrada, Flavio; Suárez, Johan

Influence of Facial and Occlusal Characteristics on Gummy Smile in Children: A Case-Control Study

Pesquisa Brasileira em Odontopediatria e Clínica Integrada, vol. 16, núm. 1, 2016

Universidade Estadual da Paraíba

Paraíba, Brasil

Brazilian Research in Pediatric Dentistry and Integrated Clinic 2016, 16(1):25-34
DOI: http://dx.doi.org/10.4034/PBOCI.2016.161.03
ISSN 1519-0501

Original Article

Influence of Facial and Occlusal Characteristics on Gummy Smile in Children: A Case-Control Study

Diana Barbosa[1], Lucia V. Bernal[1], Oscar Zapata[1], Andrés A. Agudelo-Suárez[1], Laura Angel[2], Flavio Estrada[2], Johan Suárez[3]

[1]Professor, Faculty of Dentistry, Universidad de Antioquia, Antioquia, Colômbia.
[2]Orthopedics graduate student, Faculty of Dentistry, Universidad de Antioquia, Antioquia, Colômbia.
[3]Dentist, Universidad de Antioquia, Antioquia, Colômbia.

Author to whom correspondence should be addressed: Diana Barbosa. Faculty of Dentistry. University of Antioquia. Calle 70 No. 52- 21. Medellín-Colombia. Phone: +5742196772, +573168297717. E-mail: dimabarbosa@gmail.com.

Academic Editors: Alessandro Leite Cavalcanti and Wilton Wilney Nascimento Padilha

Received: 30 April 2014 / Accepted: 17 September 2015 / Published: 18 January 2016

Abstract

Objective: To determine the association between occlusal and soft tissue characteristics with the presence of gingival smile (GS) in a pediatric population with inter-transitional mixed dentition. **Material and Methods:** Case-control study was performed with a probabilistic sample of 163 children in inter-transitional mixed dentition (age:8.8 years ±0.8). Cases were 37 children with GS, and controls were 126 children without GS. Occlusal variables were assessed through clinical examination, and soft tissue variables were assessed through photograms. Kappa test and intraclass correlation coefficient were done (0.87-0.96). The association between malocclusion, gender, and types of smile was assessed using a Chi square test. Comparison of quantitative variables in smile groups was made by Student t test. A multivariate binary logistic regression was performed. **Results:** Class II malocclusion, short upper lip at smile and short incisor clinical crown, were risk factors for gummy smile (OR= 10.4, 95%CI 3.07- 34.95, OR= 2.1, 95%CI 1.44- 3.13 and OR= 2.5 95%CI 1.34- 4.54 respectively). Lower facial height was a protective factor against GS (OR= 0.76; 95%CI 0.69- 0.85). The logistic regression model explains 48% of GS variability. **Conclusion:** Class II malocclusion is considered a risk factor for gummy smile. Other variables associated to gummy smile were short upper lip and short incisor clinical crown. Clinicians should considered these aspects in clinical examination of each patient to provide an adequate diagnostic and plan of treatment to control and/or correct a GS.

Keywords: Smiling, Case-Control Studies; Risk factor; Malocclusion, Angle class II..

Introduction

Smile evaluation is a key factor during clinical examination of orthodontic patients. The smile is very important for facial expression and critical in social interaction [1,2]. An aesthetic smile depends not only on dental aspects such as size, shape, color and position, but the amount of visible gingival tissue as well [3].

Regarding the voluntary control involved, the smile is classified as: a) *posed or voluntary*, which is static, reproducible and may or may not express emotions and b) *non posed or involuntary* [4]. The posed smile is used in most studies due to its consistency and reproducibility [5].

One of the main purposes of dental treatment is to achieve an attractive smile [6] and the amount of gingival display appears as a key factor in obtaining it [4,7]. Some authors found that the most attractive smile is present when the upper lip rests at the same level as the marginal gingiva of the upper central incisor tooth or when there is a small gingival display [8]. The gingival smile, gummy smile (GS) or high smile is presented when more than 2 mm of free gingiva are visible. This gingival display is the most undesirable aspects of the smile [9,10] and often a cause of a patient`s complaint [11,12]. On the other hand, a recent cross sectional study showed that GS is easily accepted in women by men, because they associate it with youthfulness [13]. Although GS is not pathologic, it is common in any population with a reported prevalence of 26% [11,14,15].

It is accepted that GS is normal in children and frequently is self-corrected between 15 to 18 years of age [16–18], mainly due to the changes in soft periodontal tissues and lip growth, among others. However, in some patients the GS remains over time. Taking into account that smile development is dynamic, the ideal studies to evaluate its changes are cohort studies.

In adults the GS, as a dependent variable, has been related to soft tissue, dental, skeletal and functional factors, such as size and labial inclination of upper incisors, altered overjet and/or overbite, hyperfuntion of upper lip elevators [5,7,11,16,19,20], development of skeletal and / or dental Class II malocclusion and anterior vertical maxillary excess, etc. [11,12,21]. On the contrary, the development of GS in children is not clearly established.

Most of the research in which gummy smile is treated is observational (prevalence or cross sectional) studies [1–3,5,11,14,18,19]. Others are expert opinions or cases reports [4,10]. Smile characteristics and perceptions have been described and compared in different populations and some correlations have been found [19,21]. However, case-control studies studies that try to clarify the influence of these factors on gingival smile are scarce.

Therefore, the main objective of this control-case study was to provide cientific data of association between gummy smile and occlusal, functional and soft tissue characteristics in a pediatric population with inter-transitional mixed dentition as part of an evidence-based assessment.

Material and Methods

Study Design, Setting and Data Collection

This analytical case and control study was carried out in three educational institutions in Medellin, Colombia, recruiting school children from the second to fifth grades. A population of 1,590 students was evaluated during the year September 2013 to September 2014 in order to select the case and the control group. To define the cases (GS subjects) the Peck and Peck concept was used [11], that is, gingival display during smiles higher than 2 mm. The control group (NGS) was established with subjects from the same selected schools with gingival display while smiling ≤ 2 mm. Then, all subjects who met the selection criteria as control group were included in the analysis. This smile classification was initially obtained during the clinical examination and confirmed in the photogram. Two children who didn't have gummy smile in the clinical evaluation, presented gummy smile in the photogram evaluation and were included in the gummy smile group.

The statistical calculation of sample size was obtained considering a proportion of cases risk exposed (with class II malocclusion) of 41.9% and a proportion of controls risk exposed (with class II malocclusion) of 10.9%, and a ratio of 3 controls per case (3:1), for a confidence level of 95% and a potency of 80%. The calculated sample was 24 cases and 72 controls for a total of 96 subjects.

The inclusion criteria were: Children with inter-transitional mixed dentition -because in this dental stage, overbite and overjet are stable and there are no significant occlusal changes [18]. For this study no restriction for belonging to a specific ethnic group was considered . Signing informed consent by parents or adult in charge. The exclusion criteria were children with: Diagnostic of any chronic systemic disease, Presence of craniofacial congenital malformations and/or congenital tooth absence, Suffered accidents altering the craniofacial complex, History of orthopedic or orthodontic treatment or early tooth extractions. Clinical interproximal caries

The final cases and control subjects that could be available according to the inclusion criteria was 37 cases and 126 controls (1:3.4), that is, 69% more than the minimum calculated, granting a higher potency in the study. (The age of the patients was in average 8.8± 0.8).

After obtaining the informed consent, every subject was submitted to a clinical examination that included the evaluation of molar and canine relationships to establish the malocclusion classification according to Angle, and quantity of overjet, overbite and gingival display measured during smile, using a periodontal probe calibrated in millimeters. The measurements were taken by a calibrated operator (L.A.), selected for having the best kappa coefficient of agreement (87% of concordance).

Following a described protocol [5], video clips were captured to obtain images in rest position and unforced posed smile. The video-camera was placed at a standard distance to the head (70 cm) in natural head position assisted by cephalostat. The video-clip time was fixed to 15 seconds (initiating the record two seconds before the child started to pronounce a predetermined phrase, followed by the instruction to relax and finally, to smile). Two photograms were then obtained using a computer with video edition software (Adobe Premier pro version CS3®), in JPEG format, one in resting position and another in posed smile. The photograms were exported to the program Adobe Photoshop CS® for further processing and analysis. The following variables were measured by the

software: upper lip length in rest position (ULLR), upper lip length smiling (ULLS), muscular capacity to raise the upper lip smiling (RULS), type of smile, medium facial third height (MTH), low facial third height (LTH) and incisor clinical crown height (ICCH). See Figures 1 and 2.

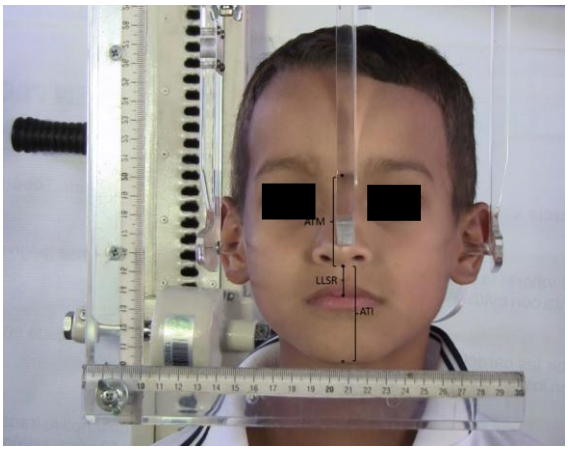

Figure 1. Rest variables. MTH: Medium facial third height; ULLR: Upper lip length at rest position; LTH: Low facial third height

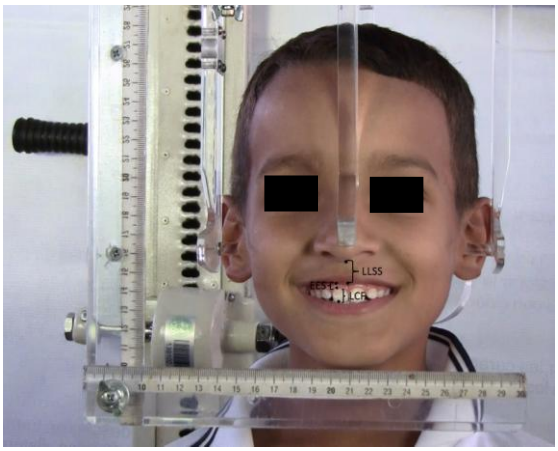

Figure 2. Smile variables. ULLS: upper lip length smiling. DGS: display gingival smile. ICCH: incisor clinical crown height

For this procedure other operator (F.E.) was previously calibrated and blinded. The intra-class correlation coefficient for repeated measurements was 0.96.

Statistical Analysis

Quantitative variables were expressed as average ± standard deviation and nominal variables were expressed as absolute and relative frequency. A bivariate analysis was used to estimate the association between type of smile and malocclusion by the chi square Pearson coefficient; the OR (Odds Ratio) was calculated to evaluate the level of risk. A multivariate analysis by binary logistic regression was used to contrast facial and occlusal variables influence on gummy smile and to identify confounding variables and interactions. The level of significance was set to $p = 0.05$. All calculations were performed using the program SPSS version 17 (SPSS Inc, Chicago, III) . In order to evaluate the goodness-of-fit for the logistic regression model the Hosmer and Lemeshow analysis were done [22].

Ethic Aspects

Parents or adult in charge of the children signed the informed consent approved, together with the protocol of this study, by the Ethics Committee of the Faculty of Dentistry, University of Antioquia, (Act of approval number 4 from June 18, 2014). The investigation was classified as of minimal risk for the subjects. The research was developed according to the principles of the declaration of Helsinki (2008) and the Resolution 8430 from the Ministry of Health of Colombia. For writing this manuscript, the STROBE guide for observational studies was used [23].

Results

From a population of 1590 children, 163 were included in the sample: 37 cases (GS) and 126 controls (NGS). In table 1 it is summarized the distribution of the two groups by age and gender. Cases and controls had similar distribution according to mentioned variables.

Table 1. Case and control groups. Distribution per age and gender.

Variable		Cases	Controls	P value
Age (years)		8,8±0,9	8,8±0,8	0,836 *
Gender	Male	21 (56.7)	76 (60,3)	0,698**
	Female	16 (43,3)	50 (39,7)	

*t test Student, **Chi-square test, Pearson.

Table 2 shows that for age, ULLR, MTH, LTH and overjet, the difference between groups was not statistically significant. In GS subjects, the average values for ICCH and ULLR are significantly lower, while RULS and overbite are higher than the corresponding values of the control group ($p< 0.05$).

Table 2. Comparison of occlusal and facial characteristics per smile groups.

Variable	Smile	$\bar{X} \pm S.D$	Range	95%CI for the difference	p value
Age (years)	GS	8.8±0.9	7.0; 11.0	(-0.28; 0.34)	0.836
	NGS	8.8±0.8	7.0; 11.0		
Upper Lip Length at rest (mm)	GS	18.5±2.2	13.7; 24.1	(-1.39; 0.22)	0.154
	NGS	19.1±2.1	12.3; 26.5		
Medium facial third height (mm)	GS	50.7±4.6	43.0; 61.1	(-1.25; 2.1)	0.618
	NGS	50.3±4.5	40.3; 63.8		
Low facial third height (mm)	GS	58.6±6.9	41.7; 77.2	(-0.68; 3.56)	0.182
	NGS	57.1±5.3	43.1; 73.0		
Upper lip length smiling (mm)	GS	13.4±1.7	10.3; 16.9	(-2.16; -0.82)	<0.001*
	NGS	14.9±1.8	11.1; 20.3		
Muscular capacity to rise upper lip (mm)	GS	5.1±1.3	0.3; 8.7	(0.37; 1.46)	0.001*
	NGS	4.2±1.5	0.0; 7.1		
Incisor clinical crown height (mm)	GS	7.8±1.1	5.9; 10.2	(-0.85; -0.01)	0.014*
	NGS	8.3±1.0	6.0; 11.0		
Overbite (%)	GS	51.9±21.3	12.5; 100.0	(6.86; 22.22)	<0.001*
	NGS	37.3±20.5	0.0; 89.2		
Overjet (mm)	GS	3.2± 1.6	-1.0; 7.0	(-0.22; 0.85)	0.243

* p≤ 0.05; 95%CI = 95%Confidence interval

According to the bivariate analysis, class II malocclusion is significantly associated to GS ($P = 0,015$). Children with class II dental malocclusion have almost thrice the risk to have GS in comparison to children that were not class II (OR 2.7 [IC 95%] 1,2 - 6,2]). No statistical significant differences were found between cases and controls respect to class III, oral habits, age and sex ($P >0.05$) (Table 3).

In the multivariate analysis model were included only variables that in the bivariate analysis presented values of p < 0,25 (table 2 and 3): Malocclusion type, ICCH, ULLR, ULLS, RULS, LTH, overbite and overjet. In final model only malocclusion class I and II were compared, because the

inclusion of class III caused a dispersion of the sample introducing confusion to the analysis as risk factor for GS. The variables with higher influence in the development of GS were: malocclusion, LTH, ULLS and ICCH (Table 4).

Table 3. Association of malocclusion, gender, breathing and oral habits versus smile type.

Variables		Cases (GS) n(%)	Controls (NGS) n(%)	OR (unadjusted) (95%CI)
Malocclusion	Class II	13 (35.1)	21 (16.7)	2.7 (1.2 ; 6.2)
	Class I	16 (43.2)	88(69.2)	
	Class III	8 (21.6)	17(13.3)	1.8 (0.6; 5.5)
Gender	Male	21 (56.7)	76 (60.3)	0.8 (0.4 ; 1.8)
	Female	16 (43.3)	50 (39.7)	
Oral breathing	Yes	6 (16.2)	16 (12.7)	1.3(0.4 ; 3.6)
	No	31 (83.2)	110 (87.3)	
Finger suction	Yes	0	0	
	No	37(100)	126 (100)	
Bruxism	Yes	1 (2.7)	5 (4)	0.6 (0.1 ; 5.9)
	No	36 (97.3)	121 (96)	

OR = odds ratio; 95%CI = 95% Confidence interval.

Table 4. Multivariate Analysis for the logistic regression model.

Variable	Adjusted OR	95%CI	p value
Malocclusion	10.4	(3.07 ; 34.95)	<0.001*
Facial low third height	0.76	(669 ; 858)	<0.001*
Upper lip length smiling	2.1	(1.44 ; 3.13)	<0.001*
Incisor clinical crown height in photogram	2.5	(1.34 ; 4.54)	0.004*

*p <0 .05 OR = odds ratio; 95%CI = 95% Confidence interval.

The model of logistic regression correctly classified 80% of the subjects as GS or NGS, but the specificity to diagnose GS was higher (82%) than the sensibility (75%). This means that the model is better to classify the absence of GS than to detect its presence (Table 5). The goodness of fit of the model, according to Hosmer and Lemeshow test [22] indicate that the difference between observed and estimated by the model values is not significant ($p > 0.05$).

Table 5. Observed versus expected frequencies predicted by the logistic regression model.

		Prediction	
Observed	**GS**	**NGS**	**Correct prediction %**
GS	24	8	75.0
NGS	19	87	82.1
% total			80.4

The four variables included in the model (Malocclusion type, LTH, ULLS, ICCH) explained 48% of the variability in the frequency of GS (Coefficienf of Regression R^2 of Nagelkerke), which indicates that other variables, not included in the present study, may have additional influence on the presence of GS.

The logistic model of regression obtained in the present study provides the following equation to estimate the probability to have gummy smile as P ≤0.25:

$$P(Gingival\ smile) = \frac{1}{1 + \exp(2.467 - 0.753(ULLS) - 2.338(MO) - 0.904(ICCH) + 0.277(LTH)}$$

In this equation ULLS stands for upper lip length smiling; MO = malocclusion, ICCH = incisor clinical crown height and LTH = low third height

Discussion

Smile characteristics have great influence in facial aesthetics and social interaction [3]. Although GS has been considered as a negative aspect in the perception of an aesthetic smile [11,14], a new published study denied this concept [13]. Consequently, it is important to obtain early data to detect risk factors.

Previous studies about sexual dimorphism for gummy smile indicate that women present higher gingival display than men [11,24,25]. In the present investigation this sexual difference was not significant. This finding may be related to the age of the studied population because facial growth is not finished [26]. Regarding racial differences, African-Americans displayed significantly more gingival tissue than any other race (25). In this study, black patients were not found.

The influence of ICCH had been considered as a factor related to GS [19]. The findings of this study indicated that long clinical crowns reduce the probability of GS. However, in a study of adolescents it was found that ICCH was slightly shorter in the GS group without significant differences from NGS group [11].

In the matter of upper lip height, previous literature reports are controversial. While, some authors [7,27] consider that a short upper lip is one of the main causal factors for GS, others have found that ULLS is equal or even slightly higher in GS subjects [11,19,28]. This study found that upper lip height in rest position or smiling was shorter in the GS group. Differences between studies might be explained by age differences in the populations because the peak of puberal growth includes acceleration in lip growth [27].

RULS is considered by some authors as the factor in muscle efficiency involved in GS [11,19,27]. It is likely that GS subjects present hyperactivity of the elevator muscles involved in the change from resting position to smile. "Muscular gummy smile" is a kind of classification used to described a GS due to muscular factors [9]. A recent systemic review showed that injection with botulinum toxin is a novel, safe and cosmetically effective treatment for GS [20]. This suggests the role of the muscle function in gummy smile. Regarding overbite, previous studies, have also found significant differences for both overbite and overjet in GS and NGS groups[11,12,24]. This is relevant for treatment of GS patients because if GS is of alveolar etiology, correction of overbite and / or overjet could help to solve this problem.

The influence of class II skeletal malocclusion on GS was studied in adolescents from 12 to 16 years old, and concluded that GS is strongly correlated to configuration and location of the

mandible [12]. Subjects with sagittal discrepancies, such as retrognatic mandíble and convex profile, represented the majority of patients with GS [12]. It has also been suggested that in subjects with mild or severe class II, there is a mechanical difficulty in lowering the upper lip [29].

Although in this study only dental malocclusion was evaluated, it is well documented that dental and skeletal malocclusions are interdependent [30,31] and therefore, it is valid to evaluate dental occlusal relationships to predict skeletal sagittal relationships. However, not using lateral cephalic X-ray images could be a limitation in the present study because other studies indicate that anterior vertical maxillary excess is one of the likely etiologic factors for GS [7,11,12,28].

The logistic regression model shows that malocclusion Class II, the increased height of the inferior facial third (LTH), a short upper lip (ULLS) and a reduced crown height (ICCH) are the most significant parameters explaining the presence of GS in this population. Conversely, a predictive model showed that the presence of GS was determined by the interaction of increased RULS, increased overbite and/or overjet, and a short clinical crown. They did not find a correlation between GS and malocclusion [19]. This dissimilarity may be related to differences of the studied population and variables introduced in the model.

A strength of this study is its appropriate design. However, the variables included in the model explain only 48% of the variation in the dependent variable (GS), which indicates that other factors remain to be identified. Although oral habits, such as thumb-sucking, oral breathing, lipsucking, etc, were not frequenly found in the target population, their presences could affect important occlusal variables. Further studies are needed to clarify their role.

The present study demonstrates that soft tissue, dental size, occlusal relations and functional factors are associated with GS. Consequently, it is recommended to include these aspects in clinical examination to provide an adequate diagnosis and treatment.

However, it is important to emphasize that gummy smile treatment is only indicated if, as an adult, the patient complains about the gummy smile for clinical or social reasons. Likewise, children with gummy smile requiring treatment must be very precisely selected. The identification of the relationship between GS and Class II malocclusion implies that correction of this kind of malocclusion helps to solve the aesthetic problems posed by OG.

Conclusions

1) Class II dental malocclusion is associated with a higher prevalence of GS. A high value of incisor clinical crown height (ICCH) and upper lip length while smiling (ULLS) must be considered protective factors against GS. Conversely, an increased overbite, increased upper lip elevation muscle activity (RULS) and an increased vertical dimension of the lower facial third (LTH) must be considered as risk factors for GS.

2) Gummy smile is associated to the complex interaction of dental, skeletal and facial soft tissue parameters.

References

1. Maulik C, Nanda R. Dynamic smile analysis in young adults. Am. J Orthod Dentofacial Orthop 2007; 132(3):307-15.
2. McLeod C, Fields HW, Hechter F, Wiltshire W, Rody W, Christensen J. Esthetics and smile characteristics evaluated by laypersons. Angle Orthod 2011; 81(2):198-205.
3. Ioi H, Nakata S, Counts AL. Influence of gingival display on smile aesthetics in Japanese. Eur J Orthod 2010; 32(6):633-7.
4. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. Am J Orthod Dentofacial Orthop 2001; 120(2): 98-111.
5. Ackerman JL, Ackerman MB, Brensinger CM LJ. A morphometric analysis of the posed smile. Clin Orthod Res 1998; 1(1):2–11.
6. Van der Geld P, Oosterveld P, Kuijpers-Jagtman AM. Age-related changes of the dental aesthetic zone at rest and during spontaneous smiling and speech. Eur J Orthod 2008; 30(4):366-73.
7. Redlich M, Mazor Z, Brezniak N. Severe high Angle Class II Division 1 malocclusion with vertical maxillary excess and gummy smile: a case report. Am. J. Orthod. Dentofacial Orthop 1999; 116(3):317-20.
8. Kokich VO, Kiyak A, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent 1999; 11(6):311-24.
9. Monaco A, Streni O, Marci MC, Marzo G, Gatto R GM. Gummy smile: clinical parameters useful for diagnosis and therapeutic approach. J Clin Pediatr Dent 2004; 29(1):19-25
10. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. J Clin Orthod 2002; 36(4):221-36.
11. Peck S, Peck L, Kataja HA. The Gingival Smile line. Angle Orthod 1992; 62(2):91-100.
12. Wu H, Lin J, Zhou L, Bai D. Classification and craniofacial features of gummy smile in adolescents. J Craniofac Surg 2010; 21(5):1474-9.
13. Pithon MM, dos Santos CR, Lima Santos N de, Aguiar Sales Lima SO, da Silva Coqueiro R, dos Santos RL. Impact of malocclusion on affective/romantic relationships among young adults. Angle Orthod 2015; 14. doi: http://dx.doi.org/10.2319/030915-146.1.
14. Guo J, Gong H, Tian W, Tang W, Bai D. Alteration of gingival exposure and its aesthetic effect. J Craniofac Surg 2011; 22(3):909–13.
15. Salud M de. Colombia. Ministerio de Salud. III Estudio Nacional de Salud Bucal. ENSAB. Bogotá ; 1998.
16. Mamandras AH. Growth of lips in two dimensions: a serial cephalometric study. Am J Orthod 1984; 86(1):61–6.
17. Mamandras AH. Linear changes of the maxillary and mandibular lips. Am J Orthod Dentofacial Orthop 1988; 94(5):405.
18. Baume LJ. Physiological tooth migration and its significance for the development of occlusion: ii. the biogenesis of accessional dentition. J Dent Res 1950; 29(3):331–7.
19. Coelho N, Alfaro P, López H. Condicionantes clínicos de la sonrisa gingival. Rev Cienc Clín 2002; 3(1):19–25.
20. Nasr MW, Jabbour SF, Sidaoui JA, Haber RN, Kechichian EG.. Botulinum toxin for the treatment of excessive gingival display: A systematic review. Aesthet Surg J 2016; 36(1):82-8.
21. Desai S, Upadhyay M, Nanda R. Dynamic smile analysis: changes with age. Am.J Orthod Dentofacial Orthop 2009; 136(3):310.e1–10.
22. Lemeshow S, Hosmer DW J. A review of goodness of fit statistics for use in the development of logistic regression models. Am J Epidemiol 1982; 115(1):92–106.
23. Von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet 2007; 370(9596):1453–7.
24. Khan F, Abbas M. Frequency of gingival display during smiling and comparison of biometric measurements in subjects with and without gingival display. J Coll Physicians Surg Pak 2014; 24(7):503–7.
25. Nanda RS, Meng H, Kapila S, Goorhuis J. Growth changes of the soft tissue facial profile. Angle Orthod 1990; 60(3):177-90.
26. Sarver DM. The face as the determinant of treatment choice. In: JJ M, editor. Front. Dent. Facial Esthet Monogr 38, Craniofacial Growth Ser. Michigan: University of Michigan; 2001.

27. Miron H, Calderon S, Allon D. Upper lip changes and gingival exposure on smiling: vertical dimension analysis. Am. J Orthod Dentofacial Orthop 2012; 141(1):87-93.
28. Singer RE. A study of the morphologic, treatment, and esthetic aspects of gingival display. Am J Orthod 1974; 65(4):435-6.
29. Graber LW, Vanarsdall RL VK. Guia interceptiva de la oclusion con enfasis en el diagnostico. Ortod. Principios y tècnicas actuales. Madrid: Elsevier; 2006. p. 423-77.
30. Meyers DM. A multivariate analysis of the relations between craniofacial structure and occlusion with DiPaolo's quadrilateral measures. Am J Orthod Dentofac Orthop 1992; 102(1):52-61.
31. Zupan S, Pohar M, Far F, Ovsenik M. Overjet as a predictor of sagittal skeletal relationships. Eur J Orthod 2008; 30(3):269-73.