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Saudi Journal of Oral and Dental Research

Abbreviated Key Title: Saudi J Oral Dent Res
ISSN 2518-1300 (Print) | ISSN 2518-1297 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article **Dental Medicine**

A New Approach for Assessing Gummy Smile: A Study on an Orthodontic Population

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DOI: https://doi.org/10.36348/sjodr.2026.v11i11.002 | **Received:** 03.12.2025 | **Accepted:** 29.01.2026 | **Published:** 14.11.2026

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Abstract

Introduction: In the literature, the definition of gummy smile has been mostly based on vertical measurements of gum exposure. The objective of this work was to determine new diagnosis criteria of gummy smile based on the correlation between the clinical, occlusal and cephalometric parameters. ***Methods:*** An analytical cross-sectional multivariate study was performed on a sample of 110 patients randomly selected from the dento-facial orthopedics department at the dental faculty of Monastir with a medium age of 17.2 years. The patients selected had no orthodontic history. A total of 77 variables were analyzed: 39 clinical parameters, 32 cephalometric parameters and 8 occlusal parameters were examined using the patients' orthodontic files [clinical examination, casts, cephalometric profile, and facial photography during smile). ***Results:*** Six variables were associated with gummy smile: low smile arc, an increased gingival display, an increased Overjet, a high value of ANB, an increased UPDH and LADH. ***Conclusions:*** Clinicians should consider these variables during the clinical examination and evaluation of the smile to provide an adequate diagnosis and treatment plan to manage gummy smile.

Keywords: Gummy Smile, Gingival Display, Smile Arc, Overjet, Cephalometric Analysis, Occlusal Parameters, Clinical Diagnosis, ANB Angle.

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INTRODUCTION

A beautiful smile can influence a person's social integration as well as his professional and personal success. It is a means of communication and spiritual connection. Thus, esthetics has become a priority and people have become more and more interested in perfecting their smiles [1].

Improving facial appearance is of crucial importance in contemporary orthodontic treatment and it is the most frequent reason bringing patients to consult. In fact, patient satisfaction is closely linked to improvement of the facial esthetic parameters [2].

The beauty of the smile depends on many factors such as teeth size, shape, color and position, the amount of exposed gingiva and the framing of the lips [1,3,4]. Although displaying a certain amount of gingiva is accepted, giving a youthful appearance, an excessive gingival display is considered unaesthetic. This excess of gum exposure gives what we call a gummy smile [1,5,6].

Many previous studies were conducted to define the gummy smile. Most of them based the definition only on the vertical measurement of gum exposure [7-10].

Thus, the main purpose of our study was to establish a new definition of gummy smile introducing other parameters in addition to gum exposure.

Secondary objectives were to quantify the influence of these parameters on the gummy smile and to use them as diagnosis tools during the clinical examination of smile esthetics.

MATERIAL & METHODS

This study is an analytical cross-sectional comparative study between two smile types [gummy smile and non-gummy smile).

It was conducted on a Tunisian orthodontic population and carried out in full accordance with the Helsinki declaration. The patients were randomly selected from the dento-facial orthopedics department at the dental faculty of Monastir in "the smile centered consultation section". The study lasted from January to December 2025.

All of the participants consulted the department to improve their smile. The patients with history of orthodontic treatment or under active orthodontic treatment during the study as well as the patients with prosthodontic restorations visible on smiling or previous orthognathic surgery were excluded from the sample.

1. Materials:

Materials used in our study:

- A digital camera: Nikon D7100 with AF-S DX NIKKOR 16-85mm F3.5-5.6G ED VR lens.
- A tripod.
- A conception device was set according to our needs to have the same framing for all patients. It is consists of a frame on which we pasted a millimetre transparent paper. The frame was fixed on a stick inside a slide that helps control the device is length along with the patient's height [Fig. 1].



Figure 1: The device used as a reference to photograph the subjects

- A graphic design software: Corel Draw x8 to take measurements from the patients' pictures.
- The patients' orthodontic folders [clinical examination's sheet, lateral cephalogram radiographs and dental casts).

2. METHODS

This study was conducted on 110 individuals. For each subject, data were compiled for 75 variables divided into two categories: Clinical and Cephalometric variables.

The clinical parameters were taken from the clinical examination sheets, dental casts and photographs.

For the photographs, the patients were seated on an adjustable chair with their heads straight. Their faces were placed 10 millimeter behind the millimeter paper to avoid the steam with the same lighting conditions.

Concerning the cephalometric parameters, the lateral cephalograms conform with ABO requirements we used.

The Statistical Package for the Social Sciences SPSS [IBM SPSS version 20, Chicago III] was used to perform the statistical analysis and Microsoft Excel for graphic descriptive representations. A Chi-square test was used for the qualitative variables and a t test for the quantitative variables to determine a correlation between the different parameters and the smile type. Finally, a

multiple linear regression was calculated. Statistical significance was set at p<0.05.

3. RESULTS

Seventy subjects of our sample representing 63.6% had a gummy smile whereas 40 representing 37.4% had a non-gummy smile. Our sample included 30% males and 70% females with a sex ratio of 0.43. There was no significant difference between females and males' proportions depending on the smile type.

We proceeded with a bivariate analysis to find a correlation between each variable and the gummy smile. Then, a multivariate analysis allowed us to obtain a relationship to classify smiles as gummy or non-gummy.

Eleven Variables were found significant in the bivariate analysis with p<0.05 divided into 6 clinical parameters and 4 cephalometric ones.

Table 1: Significant variables in the bivariate study

Variable	Gummy smile			Non-gummy smile			P
	M	SD	N	M	SD	N	
Interlabial gap at rest	1.15	2.062	70	0.395	1.190	40	0.034
Upper lip to upper incisor edge during smile	12.12	4.760	70	7.93	1.716	40	<0.001
Exposed gingival height during smile	3.86	1.924	70	-0.80	2.743	40	<0.001
Width/length ratio of maxillary left lateral incisors	0.92	0.135	70	0.83	0.270	37	0.031
Upper teeth exposure at rest	1.01	1.844	70	0.35	1.082	40	0.041
Overjet	3.46	3.006	70	1.73	2.727	40	0.003
IMPA	96.66	7.07	70	92.08	12.62	40	0.016
UADH	31.56	5.24	70	29.30	4.53	40	0.025
UPDH	25.07	3.60	70	22.58	3.70	40	0.001
LAFH/UAFH	1.299	0.147	70	1.240	0.109	40	0.029

A multivariate approach to all the parameters studied [clinical, occlusal and cephalometric] was elaborated. Only the variables that had values of p<0.05 in the bivariate analysis [represented in the previous table] were included in the multivariate model of regression. Due to the important number of the variables, the logistic model was constructed backward. We finally obtained a multivariate model of 6 variables that are respectively:

- Smile arc's situation [with 0 for low, 1 for high and 2 for medium).
- Exposed gingival height during smile.
- UPDH [upper posterior dental height).
- LADH [lower anterior dental height).
- Overjet.
- ANB.

Table 2: Multivariate analysis for the logistic regression model

	B	E.S	Wald	ddl	Sig.	Exp[B]	CI 95% for EXP[B]	
							Inferior	Superior
Smile arc's situation	-1.677	0.614	7.448	1	0.006	0.187	0.056	0.623
Exposed gingival height during smile	-1.355	0.371	13.341	1	<0.001	0.258	0.125	0.534
UPDH	-0.557	0.205	7.411	1	0.006	0.573	0.384	0.856
LADH	0.244	0.130	3.537	1	0.060	1.276	0.990	1.645
Overjet	-0.630	0.229	7.571	1	0.006	0.532	0.340	0.834
ANB	-0.181	0.159	1.296	1	0.255	0.834	0.610	1.140
Constant	7.975	4.205	3.597	1	0.058	2908.811		

The model of logistic regression correctly classified 91.8% of the subjects, as gummy smile patients or non-gummy smile patients, but the specificity to diagnose gummy smile patients was lower [85%]than the sensitivity [95.7%). This means that the model is better in classifying the presence of gummy smile than in detecting its absence. The model fits the majority of the patients. According to Hosmer and Lemeshow test, it indicates that the difference between observed and estimated values is p=0.048< 0.05 which is close to the limit of significance but it is still acceptable [11].

The six variables included in the model explained 80% of the variability in the frequency of the gummy smile.

The logistic model of regression obtained in the present study provides the following equation to estimate the probability to have a non-gummy smile as p<0.25:

Logit[p)=7.975-1.677*SAS-1.355*GE-0.557*UPDH+0.244*LADH-0.63*overjet-0.181*ANB

In this equation, SAS stands for smile arc's situation and GE stands for gingival exposure.

This equation is summarized in the ROC curve below:

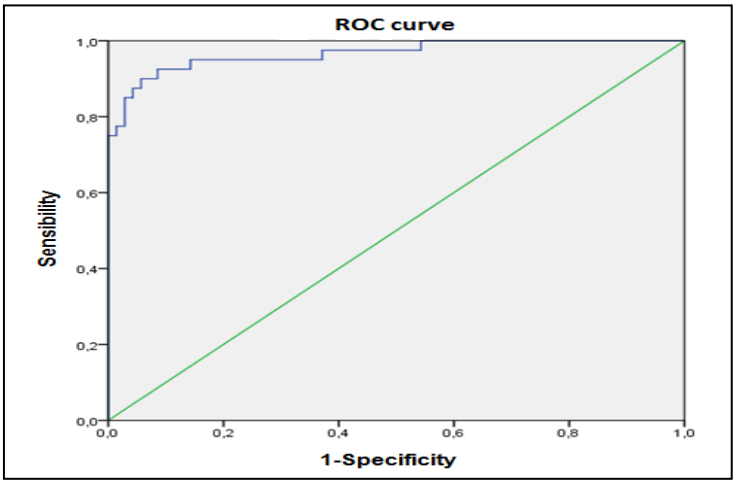


Figure 2: The ROC curve summarizing our equation

The critical score is equal to 0.38 for which the smile is considered non-gummy with 77.5% sensibility and 85% specificity. The area under the ROC curve is 0.966 >0.9 which indicates that the sensitivity and specificity we got from our equation are favorable.

DISCUSSION

The equation found was the following:
Logit[p)=7.975-1.677*SAS-1.355*GE-0.557*UPDH+0.244*LADH-0.63*overjet-0.181*ANB.
[With SAS= smile arc's situation, GE= gingival exposure, UPDH= upper posterior dentoalveolar height and LADH= lower anterior dentoalveolar height).

Among these six variables, three were in our predictive model. The variables included in the model explained 80% of the variation in the dependant variable [non-gummy smile] which is a favorable percentage.

These variables found in our regression model were different from those found by Barbosa D & al [12]in a study conducted on 163 children with mixed dentition. They worked on occlusal and soft tissue variables. In their regression model, they found four significant variables [malocclusion, facial low third height, upper lip length smiling and incisor clinical crown height in photogram] on which depends the presence of a gummy smile. Their model explained only 48% of the variation in the dependent variable.

The reasons behind this difference between our study and Barbosa's study might be the number of studied variables [we studied 87 variables while they only studied 13), the ethnic differences [South American Latinos against North Africain Berbers]and the age range chosen [they worked on a pediatric population while ours was mainly young adults).

Age is considered an important factor contributing to the smile. Children are more likely to have more gingival display than adults [13] since the aging process affects the skin, soft tissues and structural support tissues [14]. In our study, no significant difference in the mean ages of the subjects of the two smile type groups was found. This can be due to the fact that our sample is relatively young and mostly composed of teenagers. Sepolia S and co [15] found the relationship between age and the smile line situation not significant. However, Van der Geld [16] had different findings than ours. He confirmed the lowering of the of the smile line by aging. Padmasree. S [14] as well found that age and maxillary incisor's visibility had a significant relationship.

According to our study, the facial type [brachycephalic, dolichocephalic and mesocephalic] had no significant effect on the smile type. It was found in other studies [3] that the smile arc form changes depending on the facial type, which is related to the fact that the facial type has an influence on teeth form and size.

To objectively evaluate its appearance, the face is divided into vertical thirds. These thirds are based on horizontal lines drawn at the hairline, the brow line, the nasal base, and the chin. The thirds should be equal in length according to Panossian AJ *et al.,* [17]. Otherwise, a skeletal or soft tissue deformity may exist. In our study, this proportionality did not have a significant difference depending on the smile type [p=0.140> 0.05). The prominent third in case of inequality had also a very low significance [p=0,601>0.05).

The smile point is the middle of the vertical line joining the bipupillary line and the chin line. Its position should coincide with the upper lip point according to Aboucaya [18]. In our study, 60.9% of the subjects had central smile point. Aboucaya studied the smile point on a sample of 30 Merina ethnic persons. He found the central smile point in 60% of the population, which is

almost the same percentage that we found in a larger sample. However, this variable showed no influence on the smile type in our study with the value of p=0.25>0.05.

A relationship exists among the soft tissue anterior-posterior thickness in particular the upper lip, lower lip and chin [17]. If there is a difference in the thickness of these areas, the general balance of the lower third will appear less esthetic. In our study, this relationship did not show a significant difference between the gummy smile subjects and the non-gummy smile subjects [p=0.799>0.05).

The cervical line is ideally convex while the concave form [when the gingival contour of the canines is below the lateral incisors]is less pleasing [13]. The last form we found was an asymmetrical cervical line when the heights of the anterior teeth were asymmetrical. The study showed no significant correlation between smile type and cervical line's form [p=0.362>0.05] despite its clinical contribution to the smile.

The Upper lip line is the lower edge of the lip. It determines the exposure of the upper teeth [19]. Based on the lip line situation with the labial commissures, a smile can be classified into 3 types: one above the commissures or gummy smile, one commissural or cuspid smile and one below the commissures or commissure smile [18,20]. The parallelism of this variable with the pupillary line did not have a statistical importance according to our study. Our findings do not accord with Liang L Z study on a young Chinese population [20] in which he found 60.6% commissural smile and only 5.9% gummy smile. Aboucaya [18] found similar results in Merina ethnic people with 53.4% commissural smile. This difference might be the result of the ethnic differences between Chinese, Merina people and Tunisians who are, according to a genetic study conducted in 2010 by El Moncer W *et al.,* [21].

The smile arc is a hypothetical line following the edges of anterior maxillary teeth. To be considered an esthetic and youthful smile, this curvature must be parallel to the superior margin of the lower lip giving it a convex form also called a "deep plate". It is also preferable for the lower lip to barely touch or not touch the smile arc to be considered more esthetic [3, 19, 22]. In our study, the smile arc parallelism with the lower lip line, situation and form did not turn out to have a significant influence on the smile type. P values were respectively 0,634, 0.095 and 0.319 [all > 0.05). Our results support Parekh H *et al.,* [23] who studied the consonance and non-consonance of the smile arc and found no correlation between the smile arc and the smile height. However, Harati M *et al.,* [24] assumed that the smile arc form might affect the smile. On the other hand, Kaya and Uyar [25] studied the influence of both the smile arc and the gingival display on the smile perception using a series of photos digitally modified. They found a significant correlation between these two parameters combined and the way people judged the smile.

The upper and lower incisal midlines coincidence is an important criterion for a beautiful smile [26). The deviation between those two is noticed under 4mm according to a study by Kokich, [27]. Upper and lower incisal midlines' coincidence as well as their coincidence with the facial midline were not significant factors influencing the gummy smile according to our study [values of significance respectively: p=0.583>0.05, p=0.101>0.05 and p=0.856>0.05). We have found no studies that were interested in the correlation between incisal midline and the gummy smile [3]. The lip length should be roughly equal to the commissure height [22] that was almost found by comparing the mean values we found. In our study we measured the vertical distance between the commissural line [the line that joins the two commissures]and the base of the nose. Its mean value in gummy smile patients was 24.04 and 22.74 for non-gummy smile ones. This difference was not considered statistically significant [p=0. 183>0.05). Another study was conducted by Drummond and Capelli [29] looking for a correlation between commissure height and both age and gender. They found that commissure height increases significantly by aging and that it was higher amongst men.

The intercommissural distance at rest [or mouth width]is the distance between the two corners of the mouth at rest position. This study showed no significant difference between this measurement in the gummy smile group and the non-gummy smile group. This may be explained by fact that the gummy smile is more related to vertical dimension.

Philtrum's width as well as the distance between the ala of the nose did not have a significant influence on the smile type [respectively both >0.05 p=0.923 and p=0.177). We are the first to take the initiative and include these parameters in a study about gummy smile.

The upper lip height at rest is the vertical distance between the subnasal and the stomion [17, 22]. The mean value of the upper lips height at rest in our sample was 23.37 in the case of gummy smile and 22.07 in the case of non-gummy smile. This difference was statistically non-significant contrarily to our predictions. Peck and Peck [30] found that the mean value for the gingival smile line group was 22.3 against 22.3 in the reference group. So no significant correlation was found between this variable and gummy smile. Barbosa D & al [12]as well support our findings. They found no significant difference between upper lip's height in the gummy smile group and the non-gummy smile group [p=0.154>0.05). However, Alkhalaf and Sabbagh found that the higher the smile pattern is the shorter the upper lip length [31].

The upper lip height during smile mean values did not have a significant difference between the gummy smile group and the non-gummy smile group. P value was 0.785 which is higher than 0.05. However, Barbosa D *et al.,*[12] found the difference between the gummy smile group and the non-gummy smile group very high [p<0.001). Differences between the studies might be explained by age differences since our sample is older than the one in Barbosa's study. The logistic regression model showed that a high smile arc, an increased exposed gingival height during smile, a reduced UPDH, a decreased LADH, a reduced overjet and a decreased ANB are the most significant parameters explaining the presence of a non-gummy smile in this population. ANB did not have a significant p value but it was kept in the model since it had a major influence on the model.

Our study proved that the smile arc situation and the exposed gingival height as well as the occlusal relations and the dento-alveolar factors are associated with a gummy smile. Thus, they should preferably be included in the clinical examination to have a precise diagnosis of gummy smile and to guide our treatment plans as they are directly related to these specific factors.

Clinical parameters (44)		**Cephalometric parameters (31)**		
Qualitative parameters (15)	Quantitative parameters (29)	Angular measurements(11)	Linear measurements(13)	Ratio measurements(7)
1. **Smile type** 2. **Gender** 3. **Facial type** 4. **Facial symmetry** 5. **Facial third equality** 6. **Smile point** 7. **Profile** 8. **Relationship between upper lip's thickness, lower lip's thickness and chin's thickness** 9. **Cervical line** 10. **Upper lip frenum's situation.** 11. **Upper lip line** 12. **Angle's class** 13. **Crossbite** 14. **Smile arch** 15. **Incisal midline**	1. Age. 2. Lower third's length of the face 3. The two lower thirds of the face 4. Nasolabial angle 5. Philtrum's height 6. Commissural height 7. Intercommissural distance at rest 8. Philtrum's width 9. The distance between the ala of the nose 10. Upper lip length at rest: 11. Upper lip height during smiling 12. Interlabial gap at rest	1. SNA 2. SNB 3. ANB 4. IMPA 5. I/NA 6. i/NB 7. I/F 8. I/i 9. SN/GoGn 10. SN/Occ 11. SN/PP	1. AoBo: 2. I/NA 3. U*i/NB 4. UADH. 5. UPDH (upper posterior dental height): The perpendicular length from the mesial cuspid of the 6 to palatal plane. 6. LADH (lower anterior dental height): The perpendicular length dropped from lower incisor's edge to mandible plane. 7. LPDH (lower posterior dental height): The perpendicular length from the mesial cuspid of lower 6 to mandible plane. 8. UAFH (Upper anterior facial height): The distance between N and ANS. 9. LAFH (Lower anterior facial height): The distance between ANS and Me. 10. UPFH (Upper posterior facial height): The distance between S and PNS.	1. LAFH/UAFH. 2. PFH/AFH. 3. UADH/AFH. 4. LADH/AFH. 5. UADH/UPDH 6. LADH/LPDH. 7. UADH/LADH.
	13. Upper lip to upper incisal edge at rest position 14. Upper lip to upper incisor edge during smiling 15. Upper lip's thickness 16. Lower lip's thickness 17. Chin's thickness 18. Exposed gingival height during smile 19. Clinical length of upper incisors: measured from the gingival margin to the incisor's edge. 20. Clinical width of upper incisors 21. Width/length ratio of upper incisors 22. Upper teeth exposure at rest 23. Distance between upper central incisors 24. Distance between upper lateral incisors		11. LPFH (Lower posterior facial height): The distance between PNS and Go. 12. AFH (Anterior facial height): The distance between N and Me. 13. PFH (Posterior facial height): The distance between S and Go.	
	25. Distance between upper canines 26. Smile width 27. Buccal corridor space 28. Overjet **29.** Overbite			

CONCLUSION

A gummy smile is related to different factors. A low smile arc and an increased height of exposed gingiva are highly associated with a high smile line. An increased upper posterior dento-alveolar height, a decreased lower anterior dento-alveolar height and an increased overjet and ANB play a significant role in the risk of having a gummy smile.

In order to adapt an appropriate treatment of gingival smile, the orthodontist must refine the diagnosis as much as possible and establish the etiologic factors in order to avoid relapse. Therefore, treatment can include a multidisciplinary approach in some complex cases.

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