Evaluating the Impacts of Some Etiologically Relevant Factors on Excessive Gingival Display

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The literature offers limited and even conflicting information on the etiology of gummy smile. Therefore, this study aimed to evaluate smile line, hypermobile upper lip (HUL), altered passive eruption (APE), and short upper lip (SUL) distribution in a group of patients seeking dental treatment and to examine their effects on gummy smile. A total of 501 individuals (265 men, 236 women) were included in the study. The patients were grouped by gingival display, and presence of HUL, APE, and SUL were evaluated. Multivariate Logistic Regression analyses were performed to investigate the impact of possible risk factors on gummy smile. Of the individuals, 173 (34.5%) had a low smile line, 127 (25.3%) had an average smile line, 146 (29.1%) had a high smile line, and 55 (10.9%) were gummy smile patients. Individuals with gummy smile were younger than the individuals with low smile line (P < .001). As for the possible risk factors for gummy smile, age (odds ratio [OR]: 0.936; 95% CI: 0.901 to 0.972; P = .001), HUL (OR: 18.85; 95% CI: 7.82 to 45.44; P < .001), and APE (OR: 8.819; 95% CI: 3.894 to 19.973; P < .001) were found to be significant together. Gender and SUL/upper lip length were not found to have any impact on gummy smile. HUL is the primary factor that increases the probability of having gummy smile, followed by APE as the secondary factor. It seems reasonable to focus on correction of the HUL for treatment in most gummy smile patients. Int J Periodontics Restorative Dent 2021;41:e73–e80. doi: 10.11607/prd.5475

Smile is one of the most important facial expressions and known as the parameter of nonverbal communication that expresses joy. Smile affects the professional life and confidence of individuals, as well as how they socialize with others. Thus, acquiring an esthetic smile is a significant treatment goal for both physicians and patients.

An attractive smile is composed of three main parts (teeth, lip framework, and gingival scaffold) and is closely related to the amount of apparent gingiva. Smile line (SL) is an important tool utilized to evaluate whether a smile is esthetic. SL has been classified by several researchers; Liébart et al also took interdental papilla into account and evaluated it in four categories: low, average, high, and very high SL. Very high SL in which gingiva is apparent at maximum is also called “gummy smile” (GS). Such high visibility of gingiva is not homogenous in every patient, and therefore, GS was classified by Wu et al in four groups by its localization.

Etiology of GS is multifactorial. Although three conditions—hypermobile upper lip (HUL), altered passive eruption (APE), and vertical maxillary excess—mainly cause GS, short upper lip (SUL), genetics, dental plaque, and medication can also lead to excessive gingival display (EGD). Among these, HUL,
SUL, and APE are thought to be soft tissue etiologic factors resulting in EGD. There are few studies on the etiology of GS, and the literature offers limited and even conflicting information on the matter. For example, prevalence of SUL has not been reported before, and there is contradictory information on the place of SUL within the etiology of GS. Prevalence of HUL in GS has only been reported in one study, and APE, another etiological factor for GS, has only been evaluated in some specific populations. Moreover, no study has been conducted to evaluate any factor that might be a risk for GS. It is therefore important to evaluate these factors together due to the multifactorial nature of GS. Based on the gap of literature in this field, the present study primarily aimed to evaluate SL distribution and frequency of HUL, SUL, and APE in a group of patients seeking dental treatment. The secondary purpose was to examine the effects of HUL, SUL, and APE on GS.

Materials and Methods

Patients who presented to Başkent University Faculty of Dentistry for a variety of reasons between November 2019 and February 2020 were included in the study. The study was approved by Başkent University Institutional Review Board (Project no: D-KA 20/08) and supported by Başkent University Research Fund. This cross-sectional study is registered at ClinicalTrials.gov (NCT04553952) and was conducted in compliance with the principles of the Declaration of Helsinki (2008). All patients gave their written consent before participating in the study. The following inclusion criteria were applied: presence of teeth in the maxilla, and aged between 18 to 65 years. Patients who had received and/or were receiving orthodontic treatment and patients who had received prior GS treatment were excluded from the study.

All screening procedures were performed by one trained and calibrated examiner (S.A.). The kappa values were 0.961 (95% CI: 0.888 to 0.987), 0.962 (95% CI: 0.891 to 0.987), 0.954 (95% CI: 0.872 to 0.984), and 0.984 (95% CI: 0.954 to 0.995) for gingival display, HUL, APE, and SUL measurements, respectively (P < .05).

Identifying the SL

Age, gender, marital status, medical history, and medication status of the patients were recorded. All individuals were instructed to sit on a dental chair, and the measurements were taken using a millimetric ruler. SL was determined by measuring the visibility of the gingiva at maximum smile, and the patients were grouped according to Liébart’s classification as follows: (1) Class 1: excessive gingival display (≥ 3 mm; GS); (2) Class 2: high SL, 0 to 2 mm of gingival display; (3) Class 3: average SL, dental papilla is visible; (4) Class 4: low smile line, and gingival margin and dental papilla are not visible at all.

GS Classification and Evaluation of Etiological Factors

Patients who had EGD were categorized into one of the GS subcategories according to the following criteria: (1) Type I, where maxillary gingiva is seen like a band; (2) Type II, where posterior parts of maxillary gingiva are seen; (3) Type III, where maxillary gingiva is seen unilaterally; (4) Type IV, where the front part of maxillary gingiva is seen.

To determine whether an individual had HUL, upper lip mobility from rest to maximum smile was measured over the maxillary right central incisor. First, the distance between the subnasal area and the lower edge of the upper lip was measured at rest. Then the same measurement was repeated at the maximum smile. Patients with a difference of more than 8 mm between the two measurements were categorized as having HUL (Fig 1). Where the width/height ratio of maxillary incisors was > 0.85 and teeth appeared in a short and square form, presence of APE was considered (Fig 2). The midline distance between the subnasal area and lower edge of upper lip was measured; values < 20 mm in men and < 18 mm in women were defined as SUL (Fig 3). Presentation of types of GS in different patients are shown in Fig 4.
Fig 1  Measurement of a hypermobile upper lip. The distance between the subnasal area and the lower edge of the upper lip was measured (a) at rest and (b) at maximum smile. Patients with a difference of more than 8 mm between the two measurements were categorized as having hypermobile upper lip.

Fig 2  Altered passive eruption was considered if the width (w)/height (h) ratio of maxillary incisors was > 0.85.

Fig 3  Measurement of the upper lip length. This patient had a 17-mm lip length, classified as a short upper lip.

Fig 4  Clinical images of different patients having gummy smile: (a and b) hypermobile upper lip and (c) short upper lip and altered passive eruption.

Statistical Analysis

SPSS version 11.5 (IBM) was used for the data analysis. Mean ± SDs and median (minimum to maximum) were utilized for quantitative variables, and number of patients (percentage) was utilized for qualitative variables as descriptors. For quantitative variables, Mann-Whitney U test was performed to see whether there was a statistically significant difference between categories of the qualitative variable with two categories. To examine the relationship between two qualitative variables, chi-square test was used. Univariate and multivariate logistic regression analyses were utilized to determine the risk factors deemed to have an effect on the dependent quantitative variable. Statistical significance level was accepted to be .05.
Results

A total of 501 patients (265 men, 236 women) were included in the study. Of these patients, 173 (34.5%) had low SL, 127 (25.3%) had average SL, 146 (29.1%) had high SL, and 55 (10.9%) were GS patients (Fig 5). For the age variable, mean values of low, average, high, and GS groups by SL were calculated to be 43.01 ± 16.69 years, 37.46 ± 13.48 years, 33.82 ± 12.15 years, and 28.44 ± 7.87 years, respectively; statistically significant differences were found between the groups ($P < .001$). Considering the paired groups with Bonferroni-corrected Mann-Whitney $U$ test, differences between GS and high SL, GS and average SL, GS and low SL, and high SL and low SL were found to be statistically and significantly different ($P = .046$, $P < .001$, $P < .001$, and $P < .001$, respectively).

Distribution of SLs by gender is presented in Fig 6, and Fig 7 shows how presences of APE, HUL, and SUL were distributed among the GS patients. Of the GS patients, 3.6% were found to have HUL, APE, and SUL together, whereas none of the etiologic factors addressed in this study were observed in 7.3% of the patients.

In Table 1, individuals with gummy smile (GS+) and without gummy smile (GS–) are compared by the variables of age and gender and parameters of HUL, APE, SUL, and upper lip length (ULL). The mean age of GS+ patients was $28.44 \pm 7.87$ years, the mean age of GS– patients was $38.42 \pm 14.92$ years, and the difference between the groups was significant ($P < .001$). Percentage of women in the GS+ group (65.5%) was found to be higher than the percentage of women in the GS– group (44.8%; $P < .001$).

Tables 2 and 3 present results of the univariate and multivariate logistic regression analyses, respectively. In the model, the variables age ($P = .001$), HUL ($P < .001$), and APE ($P < .001$) were found to be significant together. An increase of one unit in the quantitative variable of age reduces the risk of having GS by $\times 0.936$ (95% CI: 0.901 to...
Fig 7  Distribution of hypermobile upper lip (HUL), altered passive eruption (APE), and short upper lip (SUL) in the gummy smile population.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Study population (n = 501)</th>
<th>GS− (n = 446)</th>
<th>GS+ (n = 55)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender, n (%)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>246 (55.2)</td>
<td>19 (34.5)</td>
<td>.004*</td>
<td></td>
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<tr>
<td>Female</td>
<td>200 (44.8)</td>
<td>36 (65.5)</td>
<td></td>
<td></td>
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<tr>
<td>Presence of HUL, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>103 (23.1)</td>
<td>48 (87.3)</td>
<td>&lt; .001*</td>
<td></td>
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<tr>
<td>No</td>
<td>343 (76.9)</td>
<td>7 (12.7)</td>
<td></td>
<td></td>
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<tr>
<td>Presence of SUL, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>38 (8.5)</td>
<td>5 (9.1)</td>
<td>.801</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>408 (91.5)</td>
<td>50 (90.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of APE, n (%)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>23 (5.2)</td>
<td>26 (47.3)</td>
<td>&lt; .001*</td>
<td></td>
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<tr>
<td>No</td>
<td>423 (94.8)</td>
<td>29 (52.7)</td>
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<tr>
<td>Age, y</td>
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<tr>
<td>Mean ± SD</td>
<td>38.42 ± 14.92</td>
<td>28.44 ± 7.87</td>
<td>&lt; .001b</td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>36.50</td>
<td>26.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum, maximum</td>
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<td>14.00, 47.00</td>
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<td></td>
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<tr>
<td>ULL, mm</td>
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<tr>
<td>Mean ± SD</td>
<td>22.59 ± 3.20</td>
<td>22.44 ± 3.15</td>
<td>.708b</td>
<td></td>
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<tr>
<td>Median</td>
<td>23.00</td>
<td>23.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum, maximum</td>
<td>15.00, 33.00</td>
<td>16.00, 30.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GS = gummy smile; GS+ = with GS; GS− = without GS; HUL = hypermobile upper lip; SUL = short upper lip; APE = altered passive eruption; ULL = upper lip length.
*Chi-square test.
*Mann-Whitney U test.
Presence of the HUL variable increases the risk of having GS by ×18.853 (95% CI: 7.822 to 45.442). Similarly, presence of the APE variable increases the risk of having GS by ×8.819 (95% CI: 3.894 to 19.973).

### Discussion

The purpose of the present study was: (1) to determine the distribution of SL and frequency of HUL, SUL, APE, and (2) to evaluate the impact of the HUL, SUL, and APE on GS. The study results show that a majority (34.5%) of the sample population consisted of individuals with low SL, whereas 10.9% of the study population had GS; the parameter that had the highest relationship with GS was HUL (odds ratio [OR]: 18.85; 95% CI: 7.82 to 45.44; P < .001).

Patients may smile differently depending on what they feel at a given moment, and it can lead to various natural smiles for the same patient. This makes forced smile more advantageous than natural smile in terms of repeatability. Similar to another study, the present study participants were evaluated at their forced smiles, and the evaluation of SL was based on Liébart’s classification. There are different prevalence values for the distribution of SL in various populations.7–9,22,23 Findings from the present study coincide with the results achieved by Jensen et al8 but differ from other results in the literature.7,9,22,23 The difference might be due to the fact that studies in the literature were conducted on very different populations.

It is emphasized in the literature that low SL creates a masculine smile characteristic, while high SL is attributed to a rather feminine smile characteristic.24,25 In line with another study,26 the GS+ group in the present study population is mainly composed of women; however, gender was not found to have any impact on GS. Because such a risk assessment has not been done before, it is not possible to directly compare this result with others.

In some previous studies, the condition where the upper lip
moves higher than 8 mm at maximum smile has been considered HUL. In the present study, this threshold value was used for the diagnosis of HUL, and frequency of HUL in individuals with GS was found to be 87.3%. There is one study that reports prevalence of HUL in GS patients in the literature. Unlike the study performed by Andijani and Tatakis, prevalence of HUL in the present study was also evaluated in the group of GS– individuals and found to be 23.1%. Prevalence of HUL in the GS+ group was found to be significantly higher than in the GS– group (P < .001), indicating that HUL has a significant place within the etiology of GS.

First defined by Coslet et al., APE is a condition that causes EGD, and teeth are seen shorter and in the square form in its presence. In the present study, APE was diagnosed based on the width/height ratio of maxillary anterior teeth, like in a previous study. Prevalence of APE ranged from 12% to 55% in studies conducted on specific populations. In the present study, APE was seen in 47.3% of GS+ patients and 9% of the total population. Unlike the previous study, the frequency of APE was also evaluated in individuals with GS–, and frequency of APE was found to be significantly higher in the GS+ group than in the GS– group (P < .001). This is an expected result for APE, which has an important role in the etiology of GS.

The study findings did not observe any significant difference between the groups both by ULL and SUL. In the relevant literature, contradictory findings are observed in the effect of ULL on SL. Although SUL has been reported to be a parameter that affects EGD, some researchers reported that ULL is not to be associated with GS. Schendel et al. compared ULL of individuals with and without GS and reported that both groups had the same lengths. In fact, Singer reported ULL of women with GS to be longer than those without GS. Similarly, Roe et al. reported that individuals with short and normal ULLs had no remarkable difference by gingival display. In the present study, ULL and GS were not found to be correlated.

The present study performed a risk assessment for GS, and in the multivariate logistic regression analysis, the riskiest parameter was found to be HUL, followed by APE. Because there is no study that has conducted a risk assessment for GS in the literature, it is not possible to compare these results. Alternatively, Andijani and Tatakis found quite a high prevalence of HUL in GS patients, coinciding with the present results.

It is notable that etiologic factors evaluated in about half of the GS+ group are present in several combinations. This result supports that GS has a multifactorial etiology and therefore its treatment requires a clinician’s mastery. APE may be resolved with gingivectomy/apical flap positioning (with and without bone resection). In case of SUL and HUL, lip repositioning surgery, which is a surgical procedure, is a treatment option. Another treatment option for the HUL is injection of botulinum toxin type A, which is a nonsurgical application. Other recommended treatment modalities are orthodontic intrusion and orthognathic surgery with or without periodontal and restorative therapy. Depending on the combination of existing etiologic factors, one or more of these treatment options can be used for the treatment of GS.

To the best of the present authors’ knowledge, this study is the first to examine the frequency of SUL in patients seeking dental treatment and to perform risk assessment for GS, thus achieving new findings in this field. However, some limitations should be considered when interpreting the results, the first of which is the lack of the evaluation of all etiologic factors, such as vertical maxillary excess or dentoalveolar extrusion. Another limitation may be that the population consisted of patients who applied to the dental faculty for several reasons. Therefore, extensive studies that evaluate all etiologic factors of GS are required to understand the role of these factors together on GS.

Conclusions

The results show that 10.9% of the study population had GS. In addition, HUL was found to be the primary factor that increased the probability of having GS, which was followed by APE, and the majority of the study population had a low SL. There was no relationship between SUL/ULL and GS. Further studies are needed to clarify and confirm these findings.
Acknowledgments

The authors declare no conflicts of interest related to this study.

References