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Original Article

Etiologies of excessive gingival display in a Saudi population

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ABSTRACT

Introduction: Excessive gingival display (EGD) is a mucogingival deformity characterized by overexposure of the maxillary gingiva while smiling. This cross-sectional study aimed to identify EGD etiologies and their prevalence in participants at King Saud University, Saudi Arabia.

Methods: Adults with a gummy smile, who resided in Saudi Arabia, were nonsmokers, had good overall health, and had all their maxillary anterior teeth were eligible for inclusion. Participants were first screened by phone, and those who met the eligibility criteria were further screened at the Dental University Hospital (King Saud University, Riyadh, Saudi Arabia). The demographic characteristics of all eligible participants were recorded. Participants were further subjected to extraoral examination, which included gingival display (GD), vertical maxillary excess (VME), hypermobile upper lip (HUL), smile line, altered passive eruption (APE), gingival overgrowth, and short upper lip (SUL). Intraoral examination included periodontal pocket depth and bleeding upon probing. Student's *t*-test was used to compare the mean GD values across the main etiologies (VME, HUL, APE, and SUL).

Results: All 123 participants (mean age: 23.1 ± 0.2 years; 74 females) had EGD (i.e., GD ≥ 4 mm), of whom 55 (44.7 %) had a single etiology, and the remaining 68 (55.3 %) had > 1 etiology. APE was the predominant etiology (n = 90, 73.2 %) in the study population. Of these (n = 90), APE alone was prevalent in 29 (32.2 %) participants, whereas the remaining patients had APE in combination with other EGD etiologies (n = 61; 67.8 %). The presence of more than one EGD etiology in the same participant was associated with greater GD. The VME and HUL were significantly associated with smile line classes ($p < 0.05$).

Conclusions: APE (alone or in combination) was the predominant etiology of EGD in the study population. The presence of multiple EGD etiologies in the same patient emphasizes the need for an etiology-based, sequential, and multiple-treatment strategy to effectively manage EGD.

1. Introduction

Excessive gingival display (EGD), also known as a gummy smile (GS) or high smile, is a mucogingival deformity characterized by the display of the entire length of the maxillary central incisor crowns with a continuous band of gingiva during smiling or speaking (Sheth et al., 2013). Studies have shown that GD ≥ 4 mm is perceived as unattractive by both dental professionals and laypeople (Kokich et al., 1999; Ker et al., 2008), and GD level is inversely correlated with perceived friendliness, trustworthiness, intelligence, and self-confidence (Andijani and Tatakis, 2019). Addressing patients' concerns with EGD requires identifying its etiology in the patient and formulating an appropriate treatment plan.

Estimates suggest 3,084,618 cases of periodontal disease in Saudi Arabia (IHME, 2020). However, evidence regarding the prevalence of EGD etiologies is limited. Therefore, this study was conducted to identify EGD etiologies in a Saudi population, determine the prevalence of each etiology, and investigate the correlation between the amount of GD and

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the presence of each etiology.

2. Methods

2.1. Study design

This cross-sectional observational study included participants who visited the Dental University Hospital (DUH) at King Saud University (KSU), Riyadh, Saudi Arabia.

2.2. Sample size calculation

The sample size was determined using G Power (Hinnerup, Denmark). The confidence level was set at 95 %, the power level at 80 % with a moderate effect size and final sample size of 100 students. However, a larger sample was recruited to avoid the possibility of a low response rate that could affect the sample size (Cohen, 1988; Sullivan, 2012).

2.3. Recruitment method

The study was conducted from July 2020 to April 2021, according to the Helsinki Declaration. The Institutional Committee of Research Ethics at KSU (No. E-20–4824), approved this protocol. Flyers were used to encourage study participation and distributed via social media (WhatsApp, Twitter, and Telegram), official KSU emails, and throughout DUH clinics. Written informed consent was obtained from all participants. The flyers offered consultation with a periodontist (R.J.) to confirm etiology of the EGD and appropriate treatment for some participants as needed. Participants were first screened via phone before coming to clinics to ensure that they met the initial eligibility criteria: being Saudi Arabian, aged $\geq$ 18 years, having a GS (participants were shown photograph of GS and asked if they had a similar smile), and no history of facial fillers or Botox treatment.

2.4. Eligibility criteria

Participants who passed the phone screening and provided consent were screened at the DUH clinic. The sex and age of each participant were recorded. Individuals aged $\geq$ 18 years, non-smokers, with good overall health, and with all their maxillary anterior teeth were eligible for participation. Participants aged $<$ 18 years, pregnant, smokers, with fixed or removable prostheses, with a history of maxillofacial surgery, or with a history of facial fillers or Botox injections were excluded.

2.5. Intra-examiner & inter-examiner reliability

Etiology measurements for EGD were performed independently by two trained examiners (E.Q., L.S.) at three different times (minimum of 24 h apart) using photographs of the participants at rest and with a maximum smile. Kappa statistics were used to assess agreement between categorical variable responses for both intra- and inter-examiner reliability.

2.6. Screening and examination

Participants' medical history and physical status were examined using the American Society of Anesthesiologists classification system (ASA, 2023). Periodontal health status was evaluated according to the 2017 update of the American Academy of Periodontology classification system (Caton et al., 2018). Photographs of eligible participants were obtained using a customized ruler (Supplementary Fig. 1). Each participant underwent identification and recording of EGD etiologies (as explained below). For radiographic evaluation, periapical radiographs of all upper anterior teeth were taken to determine APE type, while lateral cephalometric radiographs were taken to confirm VME diagnosis (explained below). Radiographs were tracked by an experienced orthodontist (F.O.) and periodontist (R.A.).

2.7. Clinical parameters

2.7.1. Pocket depth

Pocket depth (PD) was measured using William's probe with gentle pressure (0.25 N/cm^2). The probe was placed parallel to the long axis of the tooth, with a 10° inward tilt at proximal points. The distance from the gingival margin to the bottom of the gingival sulcus was measured at three points on the buccal and lingual sides. All measurements were recorded to the nearest 0.5 mm (Malkinson et al., 2013).

2.7.2. Clinical attachment level

Clinical attachment level was measured from the cementoenamel junction (CEJ) to the bottom of the probable periodontal pocket using the same probe, with measurements taken to the nearest 0.5 mm (Listgarten, 1980).

2.7.3. Bleeding on probing

Bleeding on probing was evaluated based on presence/absence of bleeding at the probing site immediately after measuring the PD (Kokich et al., 1999; Lang et al., 1990).

2.7.4. Gingival display

In maximum smile position, the amount of GD was determined by measuring the distance in millimeters from the right central incisor's zenith point to the inferior border of the upper vermilion (Fig. 1) (Andijani and Tatakis, 2019).

2.7.5. Upper lip measurements

The total upper lip length was measured at rest from the base of the nose (sub-nasal) to the inferior border of the upper vermilion (Supplementary Fig. 2). SUL was diagnosed when the total upper lip length was $<$ 19 mm for males and $<$ 17 mm for females (Tatakis et al., 2024).

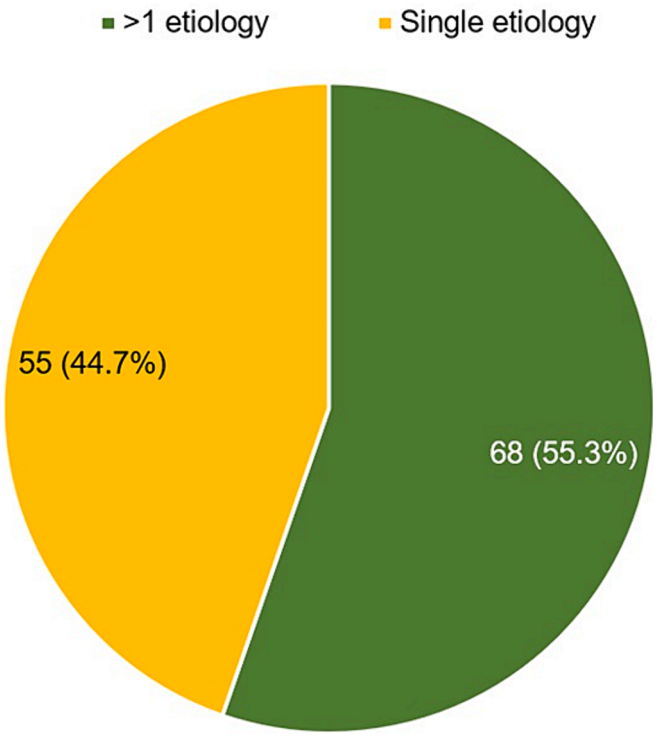

Fig. 1. Number of EGD etiologies in the study population (n = 123), **Abbreviations:** EGD, excessive gingival display.

Hypermobility of upper lip measurement: The total upper lip length from the rest to maximum smile position was measured clinically based on dynamic movement. HUL was diagnosed when upper lip mobility was > 8 mm during maximum smile (Silva et al., 2013; Liébart et al., 2004). Smile asymmetry was recorded during maximum smile when there were different levels of GD on the right and left sides.

2.7.6. Smile line

The smile line was evaluated and analyzed as previously reported (Mitchell, 2013).

2.7.7. Vertical maxillary excess

VME was diagnosed when the lower facial third was larger than the upper and middle thirds (Supplementary Fig. 3). Lateral cephalometric radiographs were obtained to confirm clinical diagnosis. Briefly, patients were instructed to have their heads in a natural position (i.e., straight ahead, relax their tongue and lips), with the teeth in maximal intercuspation oriented to the Frankfort horizontal plane. Radiographs were obtained using a cephalostat (DR-155-23HC, Hitachi Medical Corporation, Tokyo, Japan) at 100 kV and 10 mA. The distance from the focus of the X-ray device to the patient's midsagittal plane was 150 cm, and from the film to midsagittal plane was 15 cm. To eliminate inter-examiner variability, all radiographs were manually traced by an orthodontist (NJ). Cephalometric analysis of the radiographs was performed using cephalometric software (Winceph 5.5, Rise, Sendai, Japan). Five linear and two angular measurements were performed on skeletal hard tissue. Adult skeletal and dental Caucasian norms were derived from published studies (Riolo et al., 1974; McNamara Jr, 1984; Miyajima et al., 1996), and the diagnosis was confirmed when measurements were above the normal reading (Supplementary Table 1).

2.7.8. Altered passive eruption

APE was diagnosed when the width/length ratio of the upper maxillary anterior teeth was ≥ 0.85 without incisal wear (Silberberg et al., 2009; Smith and Knight, 1984; Benson and Laskin, 2001) and classified according to the Coslet classification (1977) by clinically measuring the attached gingiva and assessing the alveolar crest bone level in relation to the CEJ on periapical radiographs (Coslet et al., 1977).

2.8. Statistical analysis

Descriptive statistics were used to describe quantitative and categorical variables. Student's *t*-test for independent samples was used to compare the mean GD values across different EGD etiologies. Pearson's chi-square test was used to observe the association between categorical variables (etiologies) and smile line class. $P < 0.05$ was considered statistically significant. Data were analyzed using SPSS (version 26.0; IBM, Inc., Armonk, NY, USA).

3. Results

Overall, 123 participants were included after phone screening and clinical examination. The participants were 23.1 (SD = 0.2) years old and included 74 females (60.2 %) (Table 1; Supplementary Data 1).

3.1. Gingival display

All participants exhibited GD on maximum smiling, that was ≥ 4 mm. The mean GD was 5.42 (SD = 1.26) mm.

3.2. Smile line

Twenty (16.3 %) had high smile line (HSL) and 103 (83.7 %) had very high smile line (VHSL).

Table 1
Demographic characteristics of study participants (n = 123).

Characteristics	Study participants, (n = 123)
Age group, n (%)	
18—25 years	74 (60.2)
25—35 years	38 (30.9)
35—45 years	7 (5.7)
>55 years	4 (3.2)
Gender, n (%)	
Male	49 (39.8)
Female	74 (60.2)

3.3. Upper lip length

The mean (SD) total upper lip length was 22.13 (2.20) mm, with no statistically significant differences between males and females (22.09 [SD = 2.02] vs. 22.16 [SD = 2.35]; p = 0.865).

3.4. Prevalence of excessive gingival display etiologies

APE was the most common etiology of EGD (n = 90; 73.2 %) followed by HUL (n = 63; 51.2 %), and VME the least common etiology (n = 56; 45.5 %). No participants had SUL. Among participants with APE etiology (n = 90), 1B (88.9 %) was the most common. Regarding the smile line, 117 (95.1 %) participants had a symmetrical smile line, while 6 (4.9 %) had an asymmetrical smile. There were no statistically significant differences between males and females in the distribution of different etiologies (Table 2).

Of 123 participants, 55 (44.7 %) had a single etiology (APE = 29 [52.7 %]; HUL = 12 [21.8 %]; VME = 14 [25.5 %]). The remaining 68 (55.3 %) had > 1 etiology (Fig. 1), of whom 50 (73.5 %) had a combination of two etiologies (Fig. 2). The HUL and APE combination was the most prevalent etiology (38.2 %), with a slightly higher prevalence in males (57.7 %) than females (42.3 %). However, there was no statistically significant association between patient sex and the distribution of the number of etiologies.

3.5. Correlations between gingival display measurements and excessive gingival display etiologies

The mean GD among participants varied according to type and number of EGD etiologies (i.e., VME, HUL, and APE) (Fig. 3). As a single etiology, participants with HUL were found to have the highest mean GD (5.03 [SD = 1.35 mm]). Mean GD was highest among participants with the most combined etiologies, i.e., three etiologies (i.e., VME, HUL, and APE) (mean GD, 7.17 [SD = 1.10] mm) followed by two etiologies (i.e., VME and HUL; 7.06 [SD = 1.16] mm).

3.6. Correlation between smile line and excessive gingival display etiologies

VME and HUL were significantly associated with smile line classes. Of participants with VME (n = 56), 73.2 % had VHSL, and the remaining 26.8 % had HSL (p = 0.004). Among participants with HUL (n = 63), 92.1 % were classified as having VHSL, and five (7.9 %) had HSL (p = 0.010) (Table 3).

4. Discussion

Our results suggest that the prevalence and number of EGD etiologies varied across study participants. APE was the predominant underlying

Table 2
Distribution of categorical clinical study variables of all participants and their association with the participants' gender.

Study variables	Study participants (n = 123)	Gender Male	Female	χ^2 value	p-value
Smile line class, n (%)					
HSL	20 (16.3)	4 (20.0)	16 (80.0)	1.706	0.426
VHSL	103 (83.7)	36 (35.0)	67 (65.0)		
Symmetric smile line, n (%)					
Yes	117 (95.1)	39 (33.3)	78 (66.7)	0.722	0.697
No	6 (4.9)	1 (16.7)	5 (83.3)		
VME, n (%)					
Yes	56 (45.5)	14 (25.0)	42 (75.0)	2.650	0.266
No	67 (54.5)	26 (38.8)	41 (61.2)		
APE, n (%)					
Yes	90 (73.2)	32 (35.6)	58 (64.4)	1.408	0.494
No	33 (26.8)	8 (24.2)	25 (75.8)		
Coslet classification, n (%)					
1A	10 (11.1)	3 (30.0)	7 (70.0)	0.152	0.927
1B	80 (88.9)	29 (36.2)	51 (63.8)		
HUL, n (%)					
Yes	63 (51.2)	26 (41.3)	37 (58.7)	4.505	0.105
No	60 (41.8)	14 (23.3)	46 (76.7)		

Abbreviations: APE, altered passive eruption; HSL, high smile line; HUL, hyper upper lip; VME, vertical maxillary excess.

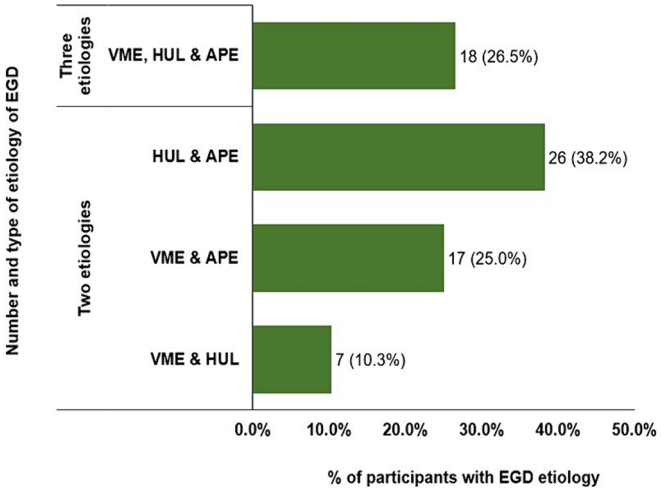

Fig. 2. Split-up of study participants with multiple EGD etiologies (n = 68), **Abbreviations:** APE, altered passive eruption; EGD, excessive gingival display; HUL, hyper upper lip; VME, vertical maxillary excess.

etiology in the study population. More than half of participants had more than one etiology, with most having a combination of two etiologies (HUL and APE). Moreover, these findings add to those of a previous study that reported an association between EGD etiologies (APE and HUL) and GD (Andijani and Tatakis, 2019), thus providing robust, clinically relevant data for the diagnosis and management of EGD.

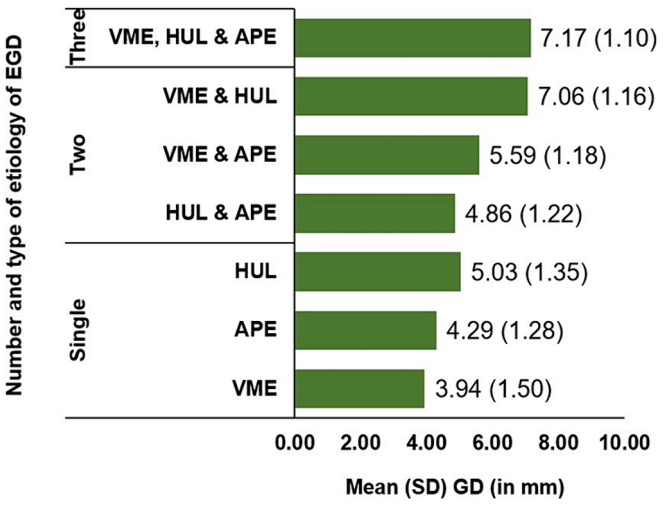

Fig. 3. Mean GD values in study participants with various EGD etiologies (n = 123), **Abbreviations:** APE, altered passive eruption; EGD, excessive gingival display; GD, gingival display; HUL, hyper upper lip; VME, vertical maxillary excess.

Table 3
Association between smile line class and EGD etiology.

Etiology	Smile line class HSL, n (%)	VHSL, n (%)	χ^2 value	p-value
VME (n = 56)	15 (26.8)	41 (73.2)	8.365	0.004*
HUL (n = 63)	5 (7.9)	58 (92.1)	6.572	0.010*
APE (n = 90)	12 (14.8)	69 (85.2)	–	–
1A (n = 10)	0 (0.0)	10 (100.0)	2.432	0.119
1B (n = 80)	16 (20.0)	64 (80.0)		

Abbreviations: APE, altered passive eruption; EGD, excessive gingival display; HUL, hyper upper lip; VME, vertical maxillary excess.
* Statistically significant.

Gingival esthetics aim to improve the overall symmetry and attractiveness of a smile. An array of procedures, including gum contouring, grafting, and depigmentation, are often used in dental practice (Humagain, 2016; Swelam & Al-Rafah, 2019; Rokaya, 2015). A holistic understanding of different etiologies provides useful insights into the selection of optimal therapeutic options for patients with EGD (Dym and Pierre, 2020). This cross-sectional study included 123 participants who underwent EGD. The participants were young (mean age 23.1 years) and mostly female (60.2 %). Participant characteristics were consistent with those reported in the literature and confirm that EGD is more common in young adults (age range: 18–45 years), with a higher prevalence in females than males (Garber and Salama, 1996; Tatakis et al., 2024; Cetin et al., 2021; de Brito et al., 2023). The total upper lip length (22.13 mm) was consistent with that reported in previous studies (Nart et al., 2014; Volchansky, 1974; Pavone et al., 2016) and supports the concept that age exerts a detrimental effect on the length of the upper lip at rest (Van der Geld et al., 2008). In a Dutch study of 122 participants (aged 22–55 years), older participants were expected to have a 4 mm increase in upper lip length compared to younger participants, which correlated with the presence of EGD (Van der Geld et al., 2008).

APE was the most common underlying etiology (73.2 %) in our evaluation, in contrast to previous studies reporting a relatively lower APE prevalence ranging between 6.9 % and 34 % (Garber and Salama, 1996; Tatakis et al., 2024; Nart et al., 2014; Volchansky et al., 1974;

Alpiste-Illueca, 2012). In a case series of patients with GS, the most common cause of EGD was HUL (45.3 %) (Garber and Salama, 1996). A US-based cross-sectional study reported that HUL was the most significant factor in determining EGD (Benson and Laskin, 2001). EGD and short teeth syndrome (STS), two esthetic smile alterations that often coexist and have a similar etiopathogenetic origin, may require simultaneous diagnosis and treatment according to specific guidelines (Pavone et al., 2016). Our findings are in line with those of previous studies that reported a correlation between APE and GS and proposed various surgical interventions for EGD and STS (Kokich, 1996; Chu et al., 2004; Monaco et al., 2004; Passia et al., 2011). Among participants with more than one etiology, most (55.3 %) had two etiologies, with HUL and APE (38.2 %) being the most prevalent combination, followed by VME and APE (25.0 %). A previous study also reported that the combination of APE and HUL was prevalent in 34 % of participants (Garber and Salama, 1996). Differences in prevalence between studies could be attributed to study population, ethnicity, and time of the studies. Among participants with more than two etiologies, 26.5 % had a combination of VME, HUL, and APE. This is notable, as none of the published studies reported the prevalence of more than two EGD etiologies (Andijani and Tatakis, 2019; Garber and Salama, 1996; Tatakis et al., 2024). Our findings also revealed that SUL was not an etiology of EGD.

In our analysis, the mean GD differed according to the type and number of EGD etiologies (Fig. 3). As a single etiology, HUL had the highest mean GD, followed by APE and VME. Multiple etiologies in a participant typically resulted in greater GD than a single etiology, specifically VME, HUL, and APE, or VME and HUL. These findings indicate that individuals with multiple underlying EGD etiologies require an etiology-based and sequential treatment approach involving more than one modality (surgical and/or nonsurgical) (Garber and Salama, 1996; Gibson and Tatakis, 2017; Ser Yun et al., 2019). Furthermore, VME and HUL were significantly associated with smile line class (i.e., VHSL was the predominant smile line class across participants with VME and HUL), which has not been previously reported.

This study has a few limitations. The cross-sectional design ruled out a causal relationship between EGD and etiology. The small sample size, recruitment from a single center, and convenience sampling method limited the generalizability of the results. Nevertheless, this is the first study to provide a comprehensive approach for identifying and recording all possible EGD etiologies.

5. Conclusions

This study revealed that APE (alone or in combination) was the predominant etiology of EGD in the study population. The presence of more than one EGD etiology in the same participant was associated with greater GD. More than half of the study participants had multiple underlying EGD etiologies, emphasizing the need for an etiology-based, sequential, and multiple-treatment approach for the effective management of EGD.

CRediT authorship contribution statement

Reham Aljasser: Conceptualization, Funding acquisition, Data curation, review & editing, Visualization, Investigation, Supervision, Resources, Project administration and Software. **Rand AL Saif:** Acquisition, Data curation, Writing – original draft, Investigation, Validation, Formal analysis, Methodology. **Lulwa AL Sohaim:** Acquisition, Data curation, Writing – original draft, Investigation, Validation, Formal analysis, Methodology. **Raghad Baidas:** Acquisition, Data curation, Writing – original draft, Investigation, Validation, Formal analysis, Methodology. **Ree, Andijani:** Data curation, Writing – review & editing, Visualization, Investigation, Project administration and Software. **Faiza Al Otaibi:** Data curation, Writing – review & editing, Visualization in Orthodontic part.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sdentj.2024.06.012.

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