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CLINICAL RESEARCH

Comparing the use of static versus dynamic images to evaluate a smile

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ABSTRACT

Statement of problem. Smile analysis, as part of the overall facial analysis, is an important component of diagnosis and treatment planning in the esthetic rehabilitation of a patient. Most studies that refer to smile analysis are based on static images. A more comprehensive evaluation can be made with dynamic video images that can be stopped at the most appropriate frame to ensure the best static images for analysis.

Purpose. The purpose of this clinical study was to evaluate the posed and dynamic smiles of both sexes, considering the type of smile, prevalence of gingival display, dental display at rest, dentogingival display at posed and spontaneous smile, and lip mobility, through digital image acquisition (photographs and video clips) manipulated by using a software program.

Material and methods. Three photographs and 1 video clip were made for each of the 380 voluntary participants aged between 18 and 32 years by using an iPhone 6 iSight 8 MP camera, Moment lens, and artificial 5500 Kelvin light (IceLight). Digital files were evaluated by using a software program (Keynote), determining each point to be evaluated with posed and spontaneous smiles.

Results. With static images, 90% of women and 74% of men had gingival display, with only 35% of women and 21% of men having continuous gingival display. With dynamic analysis, these values increased to 100% of women and 95% of men having gingival display and 62% of men and 81% of women having a continuous gingival display ($P<.05$). The difference between dentogingival display during posed and spontaneous smiles was clear, with 68% of the participants having 2.25 mm more gingival display. Women tend to show slightly more dental display at rest, posed and spontaneous dentogingival display, as well as lip mobility, than men.

Conclusions. The type of smile changes significantly when posed and spontaneous smiles are compared. Women generally show more gingiva and teeth in all the parameters evaluated than men. Dental treatments should be individually planned according to each patient's smile characteristics. (J Prosthet Dent 2019;■:■-■)

When starting esthetic dental treatment, the patient's expectations, the patient's individual anatomic characteristics, and possible therapeutic solutions should be considered.[1] Facial features and lip movements should be analyzed in relation to teeth when facial, dentolabial, and phonetic parameters are evaluated[1,2] by directly measuring the lip-tooth relationships both dynamically and at rest.[3] A pleasing smile has been shown to depend not only on tooth position, color, size, and shape but also on the amount of gingival display and the framing of the lips.[4] Clinical decisions could be affected by soft tissue display, which is normally measured from posed photographs.

The visibility of the gingival tissues depends on the position of the smile line

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Clinical Implications

Clinicians have based their treatment and research on a static analysis of patient smiles, which represents a posed smile. However, this could lead to false diagnosis and nonideal treatment because the patients' spontaneous smiles might differ significantly from the posed smiles by showing more maxillary and mandibular teeth and more gingival display. Dynamic smile evaluations should be used to determine the full range of a smile in motion.

and the relationship between the upper lip and the size and visibility of teeth.[5] Smile types can be classified as follows: a very high smile line, high smile line, average smile line, and low smile line.[5] For this analysis, both posed and spontaneous smiles need to be defined and considered. The posed or static social smile is a voluntary smile a person uses in social settings or when being photographed, while a spontaneous smile is involuntary and represents the emotion a person is experiencing at that moment.[6,7] Gingival displays within 0 to 2 mm[8] and 2 to 4 mm[4] have been reported to be esthetically pleasing, while higher or lower smile lines may present esthetic issues.[4,8]

Digital imaging has been used to evaluate different aspects of a smile, initially with static photographs.[5,8-10] However, a spontaneous smile is difficult to obtain with static photographs,[11] and capturing and quantitatively analyzing digital images acquired from videos in computer software may improve the esthetic assessment.[3,4,7,11-16]

Dentolabial parameters vary according to lip mobility in both a static posed smile and a smile in motion as captured in video.[17] The use of dynamic documentation of the smile (DDS) allows esthetic rehabilitative planning from a facial perspective, improving communication with the patient, integration among specialists, and the predictable quality of the treatment.[17] In addition, the improvements in video and photographic quality in modern smartphones make them useful for clinicians.[17] This is why, recently, protocols have been developed using smartphones, demonstrating the simplicity of their application.[17] It may no longer be essential for dentists to purchase expensive and bulky photographic equipment.

Digital analysis has revealed that women have a higher smile line than men.[5,14] Moreover, incisor display changes with age, and no individuals older than 50 years presented a high smile line.[13] This change can be explained by the elasticity of soft tissues, which decreases with age-related alterations in the connective tissue metabolism[18,19]; thus, a high smile line has been described as a sign of youth.[8,13]

Paradigms regarding smile line and the shape of teeth and their difference in men and women still exist in esthetic dentistry.[20] The concept that oval teeth were characteristic of women and square teeth of men has been disproven recently.[20] Moreover, the concept of the smile line and the normal or average display obtained from static photographs[5,10,18] may also require revision. Videos, made with several frames per second, allow the clinician to choose the optimal smile display and provide a more accurate and natural assessment than static photography.

Therefore, the purpose of this clinical study was to evaluate the smile in static and video images. The null hypotheses tested were that no difference would be found in posed and spontaneous smiles and that women and men would not show differences in the different smile parameters evaluated.

MATERIAL AND METHODS

This study was performed according to protocols approved by the institutional review board of the Universidad de los Andes, Chile. Three hundred and eighty dental students (227 women and 153 men) from the University of Los Andes, Chile, were selected; research details were explained, and the participants signed a consent agreement. Inclusion criteria specified participants should be between 18 and 32 years because different ages might affect gingival display.[13]

The operator (J.G.) was calibrated by a specialist (E.M.) to standardize and ensure the quality control of the photographs and video clips. Files used for this calibration were not used in the results of this study. Photographs and video clips were made by using an 8-MP camera (iPhone 6 iSight; Apple Inc) and a 60-mm Moment lens (Moment Inc) in artificial and standardized light calibrated in 5500 Kelvin (Ice Light; Westcott Co).

Digital imaging was made with standardized parameters: participants were requested to stand in front of a black screen, and those with long hair were asked to tie it back, with the ears showing. The digital camera was positioned 40 cm from the tip of the participant's nose for the photographs and 70 cm for the video clips. Lights were positioned on tripods at 45 degrees from the medial sagittal plane and 15 cm from the tip of the participant's nose. The digital files obtained were the following: photographs (posed smile): 1 frontal photograph with the participant's mouth closed in maximum intercuspation; 1 frontal photograph at rest (after swallowing); and 1 frontal photograph in posed smile. Participants were requested to keep their eyes focused on the horizon. Video clips (spontaneous smile): a 30-second video

Figure 1. Representative digital images from video clip. Observe how smile line changes from first (A, posed smile) to last image (F, spontaneous smile).

clip was made for each participant, aiming to make them smile spontaneously. The selected image was the one with the most dentogingival smile display (Fig. 1).

After the standardized protocol for the imaging, static and dynamic digital images were analyzed by using a presentation software program (Keynote v6.6.1; Apple Inc). Measurements were performed in the captured digital files by means of an electronic millimeter ruler (Fig. 2) that was calibrated in the photograph according to the actual width of the maxillary left central incisor. Different aspects were analyzed in the photographs and video clips.

The type of smile parameter was classified according to the study by Liébart et al[5] who determined 4 types of smile: class I, very high smile line (more than 2 mm of marginal gingiva visible, or more than 2 mm apical to the cement-enamel junction visible for reduced but healthy periodontium); class II, high smile line (between 0 to 2 mm of marginal gingiva visible or between 0 to 2 mm apical to the cement-enamel junction visible for reduced but healthy periodontium); class III, average smile line (gingival embrasures only visible); and class IV, low smile line (gingival embrasures and cement-enamel junctions

Figure 2. Different aspects measured in captured digital files by electronic millimeter ruler calibrated according to actual width of maxillary left central incisor. A, Dental display at rest measured in millimeters in frontal photograph at rest calculated from incisal edge to stomion of upper lip. B, Dentogingival display in social smile expressed by measuring (mm) distance from incisal edge of left maxillary central incisor to lower edge of upper lip following vertical line. C, Digital ruler calibrated with conventional ruler. D, Dentogingival display in spontaneous smile expressed by measuring (mm) distance from incisal edge of left maxillary central incisor to lower edge of upper lip following vertical line.

not visible). Figure 3 shows the type of smile considered for each of the 4 classifications. The type of smile was calculated as percentages for women and men at spontaneous and posed smiles. The prevalence of gingival smile display considered all the classes where gingiva was present (classes I, II, and III) and was compared between sexes for posed and spontaneous smiles.

Dental display at rest was measured in millimeters in the frontal photograph at rest and calculated from the incisal edge to the stomion of the upper lip. The measurements for women and men were compared. Dentogingival display in posed and spontaneous smiles was expressed by measuring (mm) the distance from the incisal edge of the left maxillary central incisor to the lower edge of the upper lip following a vertical line. Dentogingival display was observed for posed and spontaneous smiles for women and men, and the difference in gingival display was calculated in millimeters by subtracting posed smile dentogingival display from spontaneous dentogingival display. Lip mobility was calculated in millimeters by subtracting the dental display at rest from the dentogingival display distance in the spontaneous smile (maximum dentogingival display) for women and men. The data of prevalence of gingival smile display regarding the sexes at posed and spontaneous smiles were analyzed by using a statistical software program (IBM SPSS Statistics, v23.0; IBM Corp) by 1-way ANOVA and the Tukey HSD post hoc test (α=.05).

RESULTS

The type of posed and spontaneous smiles regarding women and men is presented in Table 1. In general, the posed smile type most frequently seen was class III (53.9% total) for both sexes, women (54.6%) and men (52.9%). The least frequently seen type was class I (5% total) for both women (7.9%) and men (0.6%). Regarding the spontaneous smile seen through dynamic videos, the previous trend changed, and more gingiva was displayed, presenting class II smile as the most frequently seen one (45.3% total) for both sexes (women 44.9%; men 45.7%), followed by class I (women 36.1% and men 16.3%), class

Figure 3. Types of smile evaluated. A, class I: very high smile line. B, class II: high smile line. C, class III: average smile line. D, class IV: low smile line.

III (women 18.9% and men 32.7%), and finally, class IV (2.1% total; 0% women and 5.2% men). It was observed that 68.4% of the sample (64.0% from men; 71.4% from women) showed a change ($P<.05$) in the type of smile from posed to spontaneous smile, whereas in 31.6%, the smile type was maintained (Fig. 4).

The prevalence of gingival smile display considered class I, II, and III, which were all classifications that show gingiva with the different types of smile and are shown in Table 2. For the posed smile, a statistically significant difference was seen ($P<.05$) when compared with spontaneous smiles in both men and women. For both posed and spontaneous smiles, women presented a higher percentage of gingival display than men. For the posed smile, a total of 83.7% (318 of 380 participants) showed papillae or more, whereas for spontaneous smiles, this value increased to 97.9% (372 out of 380).

Dental display at rest, posed and spontaneous dentogingival display, lip mobility, and difference in gingival display between posed and spontaneous smiles regarding the sexes are shown in Table 3. Slightly higher values were found for all factors in women. Moreover, the minimum and maximum values (lower standard deviation) were closer to each other for women for all factors when compared with men.

Table 1. Prevalence of type of smile (%) with respect to sexes with posed and spontaneous smiles

	Type of Smile			
	Posed		Spontaneous	
Type of smile	Women (%)	Men (%)	Women (%)	Men (%)
Class I	7.9	0.6	36.1	16.3
Class II	27.7	20.3	44.9	45.7
Class III	54.6	52.9	18.9	32.7
Class IV	9.7	26.1	0	5.2

DISCUSSION

The first null hypothesis tested was rejected because the predominant types of smiles changed from posed to spontaneous. In posed smile, the highest prevalence of type of smile was the average (53.9%), but when evaluated in spontaneous smile, a greater part of the teeth started to show in the smile, and most of the participants presented a high smile line (45.3%; 2 to 4 mm gingival exposure). In total, most participants presented a change in type of smile from posed to spontaneous (68.4%).

Different studies have observed the importance of type of smile and smile lines.[1,3-5,7-13,16] For posed smiles, the low smile line was the most frequent, whereas the average smile line was the most frequent in spontaneous

Figure 4. Observed changes in women and men. Posed smile visualized through digital photographs and spontaneous smile through video clips. Observe that photographs from A to D did not show change in type of smile from posed to spontaneous smile, whereas photographs from E to H showed changes. Change in type of smile corresponds to bigger lip movement from posed to spontaneous smile. A-D, "no change in type of smile" and "change in type of smile" images from women. E-H, "no change" and "change" images from men.

Table 2. Prevalence of gingival smile display with respect to sexes with posed and spontaneous smiles

	Type of Smile	
Gingival Smile Display	**Posed (%)**	**Spontaneous (%)**
Men	73.8[B]	94.8[B]
Women	90.3[A]	100[A]

Means followed by different superscript uppercase letters vertically differ statistically from each other ($P<.05$).

Table 3. Dental display at rest, posed and spontaneous dentogingival display, lip mobility, and difference in gingival display between posed and spontaneous smiles with respect to sexes (mm) (minimum to maximum)

Smile Characteristic	**Men**	**Women**
1. Dental display at rest	1 (0-6.5)	1.2 (0-6.5)
2. Posed dentogingival display	7.8 (2-12.5)	8.8 (4-14)
3. Spontaneous dentogingival display	10.1 (3.5-16.5)	11 (6-17)
4. Lip mobility (subtraction 3-1)	9.1 (3.5-18)	9.8 (5-15)
5. Difference in gingival display (spontaneous minus posed)	2.2 (0-9)	2.2 (0-8)

smiles.[9] Another study reported the average smile line as the most frequent for both posed and spontaneous smile lines.[5] All these studies are consistent with the present study if the posed static smile is considered. If any of the classifications of Tjan et al,[10] Liebart et al,[5] and Jensen et al[18] are used, a total of 81% of women and 62% of men show a gingival display, making this group the most common and not in need of any kind of correction. Nevertheless, there is a threshold of display that tends to be less attractive, which the authors believe lies at 4 mm of display. The evaluation of this threshold should be a matter for future investigations. However, when individuals smile spontaneously, this pattern changes, and what was previously considered a high smile line is predominant, corroborating the importance of the dynamic assessment. It is nearly impossible to capture the highest smile line of a patient in a single photographic image,[11] which is why video recording is indicated. Studies that used videography also reported changes when smile parameters were evaluated between posed and spontaneous smiles.[11,13] This is consistent with this study and demonstrates that a video recording is indicated when the spontaneous smile requires evaluation.

Such information is relevant for patients with excessively short teeth, excessive gingival display, or lack of tooth display frequently associated with esthetic problems.[21] The results of the present study show that gingival display is normal for most individuals, which will help the clinician look for other discrepancies such as tooth length-width ratio, wear, altered passive eruption, alveolar extrusion, or skeletal vertical maxillary excess. In the authors' clinical experience, when a patient complains of excessive gingival display, the problem is often because of other undetected problems such as uneven gingival zeniths or tooth ratio discrepancy. Treatment options might involve crown lengthening alone or in conjunction with restorative treatment.[21]

The second null hypothesis was also rejected because for all parameters evaluated, (dental display at rest, posed dentogingival display, spontaneous dentogingival display, lip mobility, and the difference between posed and spontaneous dentogingival display), women showed higher values for visible teeth. Although the dental gingival display difference at rest between women and men was only about 0.23 mm, the difference between the sexes regarding posed and spontaneous dentogingival display and lip mobility was about 1 mm. Moreover, although more women than men were evaluated in this study (227 to 153), which could be reflected in higher differences between the maximum and minimum values of the parameters evaluated, this was not found, indicating that women had more standardized smile patterns than men. One millimeter can be the difference between an esthetically favorable and unfavorable smile because the type of smile classification varies from 0 to 4 mm, and values within those limits are considered extremes. These results are also consistent with those of previous studies showing that women display more gingiva than men.[10,14]

When gingival display in women and men was evaluated, similar mean values were obtained (2.24 mm gingival display for men and 2.25 mm for women). This mean is consistent with the esthetic smile as defined in previous studies. These studies reported that a gingival display of between 0 and 2 mm is acceptable to dentists and lay people[8] and that a smile line height of between 2 and 4 mm is perceived most favorably.[4] Therefore, with the average increase in the spontaneous smile of around 2.24 mm for men and 2.25 mm women, most of the participants evaluated in this study would be considered as having an esthetically favorable smile.

Although gingival display appears to have a negative social connotation, 36.1% of women exposed more than 2 mm of gingival tissue in spontaneous smiles. Additional studies are needed to determine the threshold of gingival display for an esthetically unpleasant smile.

This study used the technology of videographic imaging, which provides the opportunity to select images that best reflect the specified function among numerous frames that are obtained over time.[6,11-13] Videography appears to be reliable, reproducible, and valid for use in clinical practice.[22] After making the videos, analysis and measurements can be performed by using a software program.

This study was limited to a single age range because it has been shown that maxillary incisor display changes with age.[13] Further studies should focus on type of smiles, changes during spontaneous and posed smiles, and smile characteristics such as lip mobility and dental and

dentogingival display in different age ranges. This study showed that the use of digital photographs alone for evaluation and treatment planning is incomplete because most of the participants showed a change in the type of smile from posed to spontaneous records. Moreover, treatments should be planned individually because a wide range of maximum and minimum values for lip mobility, dental and dentogingival displays at rest, and posed and spontaneous smiles was observed. Women usually present higher dentogingival display in both posed and spontaneous smiles than men.

CONCLUSIONS

From the findings of this clinical study, the following conclusions were drawn:

1. Unlike previous reports, a high smile line (class II) was the most frequent type of spontaneous smile seen (45.3%) in this young population (18 to 32 years old), while an average smile (class III) was the most frequently seen one when the smile was posed (59.9%).
2. Around two-third (68.4%) of the participants changed the type of smile when posed and spontaneous smiles were compared, showing a higher smile line when a spontaneous smile was presented.
3. Women tended to display more teeth than men, reflected in the higher percentages of gingival smile display.
4. Women tended to present slightly higher dental display at rest, posed and spontaneous dentogingival display, lip mobility, and difference in gingival display between posed and spontaneous smiles than men.
5. The present study demonstrated that gingival tissue is typically shown when people smile naturally, a fact that should lead the clinician to consider it standard and not in need of treatment. When patients complain about excessive gingival display, the clinician should look for other responsible elements.

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