Smile Aesthetic Evaluation on Video Graphs: An Intra-Rater and Inter-Rater Agreement Study

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Introduction

The smile of patients is a sign of their satisfaction at the end of the treatments but also of their complexes before care. Several studies have shown that the aesthetics of the smile is a major concern for patients and has a significant impact on facial attractiveness [1-3]. Recently, the Smile Esthetic Index (SEI) has been proposed as a reliable and reproducible method to evaluate the aesthetics of a smile using photographs [4-5]. However, the visibility of the periodontium inevitably varies depending on whether the smile is “natural” or “forced” and thus appears to be difficult to assess objectively on photographs [6-7]. Indeed, when the dentist asks the patient to perform a forced smile in front of the camera lens, the patient displays less than the actual maximum smile height [8]. In plastic and reconstructive surgery, studies [9-10] have evaluated the smile dynamics and soft tissue changes that occur as the face transitions from the resting to the maximum smile position. These studies have shown that the evaluation of the smile should be done on a dynamic capture of this mimic rather than on static captures. Some authors [11], using videography, showed that the average duration of a spontaneous smile was 500 ms, which confirms the difficulty of capturing this very brief moment by photographs.
However, it is in the amplitude of the smile or even the laughter that the patient and his family will judge the aesthetic results of periodontal treatments [12]. Some authors [13] compared the use of videography and photography to assess the aesthetics of the natural and forced smile. They concluded that videography provided diagnostic information that could not be obtained with photography alone, but also that video graphic images should be preferred to still images by professionals. Currently, video graphs are used in restorative or prosthetic dentistry as well as in orthodontics to evaluate teeth and their aesthetics during the smile [14-16]. For example, some authors [17] evaluated the influence of a medial diastema on smile aesthetics by orthodontists, prosthodontists, and laypersons on video graphs of a frontal smiling face. In contrast, in periodontics, gingival aesthetics has been assessed primarily on photographs [5,12]. A recent review of the literature concerning the evaluation of gingival aesthetics after root coverage concluded that recording short video graphs before and after surgery could more accurately reflect the visibility of the periodontium during smiling and speaking and therefore would allow a better aesthetic evaluation of the results obtained than with the use of photographs [18]. The purpose of our study was to reproducibly evaluate on video graphs an aesthetic score (SEI) previously validated on photos.

Materials and Methods

This inter-intra rater agreement study was approved by our university hospital (Assistance Publique - Hôpitaux de Marseille, AP-HM), under registered number n° 2019-106. An informed consent authorizing the anonymous use of the video graphs was obtained for each patient. Patients, were selected over a 6 months’ period (from 01/01/2019 to 30/06/2019) according to the following inclusion criteria:

- Age >18 years.
- Healthy and/or reduced periodontium.
- Full dental arch in the maxilla (at least 15 to 25)
- Coming to consult with the investigator at the periodontology department, AP-HM.
- The calculation of the sample size (n=65) was done only to validate on video graphs the feasibility of using a score already validated on photographs [4].

Investigator/Evaluators

Only one investigator (the resident), recorded, edited, and numbered the video graphs. Three evaluators (one resident, two teachers in Periodontology) evaluated the video graphs according to the SEI [4]

Equipment for the Acquisition of the Video Graphs, Their Editing, Storage and Viewing

A smartphone (Apple iPhone 8©, Apple, California, USA) whose lens was positioned in the middle of the Smile Lite MDP©, (Smile Line, St-Imier, Switzerland) chosen to reproduce the same luminosity and mounted on a 160cm tripod with a 360° 3D swivel head (AMZDEAL tripod Camera 160cm ©, AMAZON, Seattle, USA) was used. The editing software (iMovie©, Apple, California, USA) of the videography allowed us to keep the most relevant moments of the video graphic sequences. The video graphs were in MPEG-4 format with a resolution display of 1920 × 1080 pixels. An IPad2© (Apple, California, USA) and a MacBook Pro© (Apple, California, USA) computer were used to view the video graphs and collect the data.

Conducting the Standardized Videography

Position of the Investigator

Sitting in an operator chair behind the lens at the same height and facing the subject (front position).

Position of the subject being evaluated. At 35cm from the camera lens, sitting on an operator’s chair with the back against the backrest in a straight.

Position, the Two Feet on the Ground, and the Bi-Pupillary Plane Parallel to the Ground.

After the frontal shot, the investigator rotated the seat so that the subject was in profile (side position) and then ¼ positions [15-10].

Realization of the Shooting: Scenography

To obtain and capture a natural smile but also a large spontaneous smile and laughter, the scenography was broken down into 3 steps:

a) Confidence building and relaxation of the subject: The investigator asked 3 simple questions: What is your name? Where are you from? Why are you here today?

b) Ask the subject to make a natural and a forced smile.

c) Pronunciation by the investigator of 3 funny sentences, asking the subject to repeat them. Two French tongue twister “Les chaussettes de l’archiduchesse sont-elles sales ou archi-sales?” “Tes laitues naissent-elles ? Yes, mes laitues naissent” that can be translated in two English tongue twister « she sells sea-shells by the sea-shore » “If Peter Piper picked a peck of pickled peppers, how many pickled peppers would Peter Piper pick?”And to finish with the last sentence was “Pretend to be happy to see me and have a good time” in order to get a smile or even a spontaneous laugh in order to uncover the gum to the maximum. This scenography started again from step 2 after each change of position (left side, ¼ left, front, ¼ right, right side positions).

Editing Of the Video Graphs

The aim of the editing was to select the passages corresponding to the analyzed criteria in the shortest possible time. Arbitrarily, a duration of 45 seconds was chosen for the complete video sequence.

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Data Collection

The video graphs were anonymized and numbered chronologically from 001 to 065. The questionnaires (Figure 1) were available on an online customized Google forms that allowed data collection. The score (with a maximum of 10 points) was calculated as the sum of the marks attributed to each of the 10 answers: yes = 1 point; no = 0 point. First, a training phase consisted in watching video graphs and understanding each question of the questionnaire by the 3 raters together. Then, separately, each rater watched as many as they wanted each video with the possibility to stop and go back and filled the online google forms. The calculation of the intra-individual variation (intra-rater agreement) consisted of each rater filling again the online questionnaire on Google forms one week after the first evaluation. To avoid bias, the order of viewing (and their numbering) of the video graphs of the 2 consecutive viewings one week apart was determined using 2 online randomization tables (https://www.randomizer.org/) to ensure that the rater did not remember his previous answers.

### Table: Example of Video Graphs

| Question                      | Options |
|-------------------------------|---------|
| 1. CORRECT SMILE LINE         | Yes, No |
| 2. CORRECT FACIAL MIDLINE     | Yes, No |
| 3. CORRECT TOOTH/CROWN ALIGNMENT | Yes, No |
| Question                                                                 |   |   |
|-------------------------------------------------------------------------|---|---|
| 4. ABSENCE OF VISIBLE TOOTH DEFORMITY (Are the exposed teeth not abraded and not showing any crown form alteration?) |   |   |
|   □ Yes                                                                 |   |   |
|   □ No                                                                  |   |   |
| 5. ABSENCE OF VISIBLE TOOTH DISCHROMY (Do the exposed teeth show a homogeneous colour, without any dischromy?) |   |   |
|   □ Yes                                                                 |   |   |
|   □ No                                                                  |   |   |
| 6. ABSENCE OF VISIBLE GINGIVAL DISCHROMY (Does the gingiva of the exposed teeth show a homogeneous colour, without any dischromy, such as inflammation, amalgam tattoo, white spot/area from previous free gingival graft?) |   |   |
|   □ Yes                                                                 |   |   |
|   □ No                                                                  |   |   |
| 7. ABSENCE OF VISIBLE GINGIVAL RECESSIONS (Are the gingival margins of the exposed teeth correctly located and covering the cemento-enamel junction?) |   |   |
|   □ Yes                                                                 |   |   |
|   □ No                                                                  |   |   |
8. ABSENCE OF VISIBLE GINGIVAL EXCESS (Is the gingival profile homogeneously integrated with the adjacent area on the bucco-lingual aspect, without any gingival excess – such as bulky profile in correspondence with a gingival area treated using a very thick connective tissue graft?)

☐ Yes
☐ No

9. ABSENCE OF VISIBLE GINGIVAL SCARS (Is the superficial texture of the mucogingival complex homogeneous, without any scars or superficial clefts?)

☐ Yes
☐ No

10. ABSENCE OF VISIBLE DIASTEMA AND/OR MISSING INTER-DENTAL PAPILLAE (Is an interdental diastema absent? Do the interdental papillae of the considered smile completely fill in the interdental spaces)

☐ Yes
☐ No

Figure 1: Smile Esthetic Index (Rotundo & al., 2015) questionnaire customized on Google forms to collect responses. The score (with a maximum of 10 points) was calculated as the sum of the marks attributed to each of the 10 answers: yes = 1 point; no = 0 point.
Statistical Analysis

Cohen's Kappa tests were calculated to obtain intra-rater agreement on each of the 10 questions for each rater, and a Fleiss' Kappa test to obtain inter-rater agreement on each of the 10 questions. Cohen's Kappa results were interpreted according to Landis and Koch's scale [19]. XLstat software, version 3.1 (Addinsolft®) was used to perform the statistical analysis. Statistically significant difference was set at p<0.05.

Table 1: Intra-individual variation among the 3 raters for the 10 SEI question.

| Questionnaire       | Rater 1 | Rater 2 | Rater 3 |
|---------------------|---------|---------|---------|
| MEAN                | 0.73    | 0.64    | 0.67    |
| Min                 | 0.46    | 0.3     | 0.42    |
| Max                 | 1       | 0.99    | 0.98    |

Table 2: Assessment of the level of agreement according to Landis and Koch[19].

| Strength of agreement | Kappa values |
|-----------------------|--------------|
| Poor                  | < 0.00       |
| Slight                | 0.00-0.20    |
| Fair                  | 0.21-0.40    |
| Moderate              | 0.41-0.60    |
| Substantial           | 0.61-0.80    |
| Perfect               | 0.81-1.00    |

Table 3: Inter-individual variation by Fleiss' Kappa test of each of the 10 SEI questions among the 3 raters. The lowest agreement was obtained for the absence of visible excessive gingiva (Fleiss' kappa = 0.31), whereas the highest agreement (Fleiss' Kappa = 0.90) was obtained for the absence of diastema and/or missing inter-dental papilla.

| Questions                                           | Fleiss' kappa | p-value          |
|-----------------------------------------------------|---------------|-----------------|
| 1 (Correct smile line)                              | 0.72          | <0.0001         |
| 2 (Correct face medline)                            | 0.51          | <0.0001         |
| 3 (Correct tooth crown alignment)                   | 0.55          | <0.0001         |
| 4 (absence of visible tooth deformity)              | 0.47          | <0.0001         |
| 5 (absence of visible tooth dyschromy)              | 0.73          | <0.0001         |
| 6 (absence of visible gingival dyschromy)           | 0.65          | <0.0001         |
| 7 (absence of visible gingival recessions)          | 0.69          | <0.0001         |
| 8 (absence of visible gingival excess)               | 0.31          | <0.0001         |
| 9 (absence of gingival visible scars)               | 0.39          | <0.0001         |
| 10 (absence of visible diastema and/or missing inter-dental papilla) | 0.9           | <0.0001         |

Results

Our sample consisted of 24 men and 41 women, i.e., 36% men and 64% women. The age of the subjects ranged from 21 to 74 years (mean age 33 +/- 11.3 years). The intra-rater agreement rates of the 3 raters were 0.73, 0.64 and 0.67, (Table 1) which is a substantial agreement according to Landis & Koch (Table 2) [19]. For the 10 SEI questions, inter-individual variations ranged from 0.31 to 0.90 depending on the question (p<0.001). The lowest agreement was obtained for the absence of visible excessive gingiva (Fleiss' kappa = 0.31), whereas the highest agreement (Fleiss' Kappa = 0.90) was obtained for the absence of diastema and/or missing inter-dental papilla (Table 3).

Discussion

The analysis of the smile by the periodontist is a key step in the understanding of the patient’s expectations, the diagnosis, and the establishment of therapeutic proposals. The aesthetics of the smile is based on a global harmony between the labial frame, the gingival frame and the teeth [20]. Without forgetting its subjective character, the beauty of a smile is evaluated from facial references and criteria related to the teeth and the periodontium such as the shape and the colour of the teeth, the gingival contour and the smile line [21-23]. Currently, the Smile Esthetic Index, based on the evaluation of 10 variables, is the only reliable and reproducible method to objectively quantify the aesthetic value of a smile.4. A
number (0 or 1) is attributed to each of the variables according to their presence or absence and the total score corresponds to the SEI of the subject (from 0, very bad to 10, very good). To date, the SEI has only been validated on photographs whereas the recording of short video graphs seems to allow a more accurate appreciation of the visibility of the periodontium during the smile and thus a better aesthetic analysis [18]. Our sample consisted of 24 men and 41 women, i.e., 36% men and 64% women. In our study there were more women than men, in fact our method of recruitment over time reflects the higher proportion of women than men coming to our periodontal department as shown in a recent study [24]. Our results showed a mean inter-individual reproducibility of 0.59 [0.31-0.90] and a mean intra-individual reproducibility of 0.68 [0.64-0.73], demonstrating the feasibility and reproducibility of quantifying the aesthetic value of a smile from a videography. In the original photographic study, Rotundo et al. achieved a mean inter-individual reproducibility of 0.45 [0.17-0.75] based on Fleiss’ kappa for SEI assessment [4]. Our higher agreement results may be partly related to the fact that our study had only three raters while Rotundo et al. had 10. In addition, our three raters were exclusively periodontists, whereas the raters in the Rotundo et al. study were more heterogeneous, including periodontists, general dentists, orthodontists, and restorative dentists.

In our study, the lowest inter-rater agreement was obtained for the question “absence of visible excessive gingiva” (Fleiss’ kappa = 0.31). In the Rotundo et al. study, the lowest inter-rater agreement was obtained for the question “absence of visible scar” (Fleiss’ kappa = 0.17) [4]. This difference can be explained on the one hand by the subjectivity of the notion of “excessive” gingiva and on the other hand by the quality of the images used as pointed out by Rotundo et al. even if the authors specified that only 5% of these images showed the presence of a scar. The highest inter-rater agreement was obtained for the question “absence of diastema and/or missing inter-dental papilla” in our study as in the Rotundo et al. study (Fleiss’ kappa = 0.90 and 0.75, respectively). According to our results and Rotundo’s, we can speculate that video graphs as photographs can be used for evaluating the SEI [4]. For several years, numerous studies have been conducted to determine the parameters of an ideal smile [25,4]. Different aesthetic scores have been proposed and validated using photographs but none, to our knowledge, has been validated using video graphs. However, videography is the only means of capturing the amplitudes of movement of the lips as well as the different angles of view of the gingiva, which are very difficult to obtain on a single photograph. Thus, when comparing the diagnostic value of photography and videography in the evaluation of a smile, Walder et al. observed a clear preference of the raters for videography, emphasizing the fact that it gave a greater amount of information than still images [13]. In addition, differences between photographs of the smile taken on different days were found in 80% of cases. Videography thus seems to allow a more faithful and reproducible evaluation of the aesthetic criteria of a smile. Chaves et al. evaluated the influence of a maxillary midline diastema on the aesthetic perception of a panel including orthodontists, restorative and prosthetic dentists and laypersons, using videography [17]. The reliability of their method was confirmed by intra-class correlation values of 0.81 for orthodontists, 0.73 for restorative and prosthetic specialists, and 0.71 for laypersons. It should be noted, however, that these values cannot be compared with our results from the Fleiss’ kappa test. Videography seems to be a particularly relevant tool in the evaluation of dent gingival aesthetics because it captures a set of mimics rarely visible on simple photographs taken in front of a practitioner [26]. In our study, we did not correlate our objective evaluation of the SEI with the patient’s subjective evaluation. This should be the subject of a future study.

**Conclusion**

Within the limits of this study, we have demonstrated that it is possible to evaluate reproducibly on video graphs an aesthetic score (SEI) previously validated on photos. It would be interesting to quantify the amount of gingival visibility on the video graphs to increase the accuracy of diagnosis and evaluation of aesthetic results. And then compare the gingival aesthetics during the smile before and after periodontal plastic surgery.

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The authors declare that they have no conflict of interest.

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**Ethical Approval:** This observational study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by our university hospital (Assistance Publique - Hôpitaux de Marseille, AP-HM), under registered number n° 2019-106.

**Informed Consent:** An informed consent authorizing the anonymous use of the video graphs was obtained for each patient.
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