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Smile Attractiveness of ABO Board Cases: A Retrospective Analysis

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Smile Attractiveness of ABO Board Cases: A Retrospective Analysis

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THESIS

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Chapter I

Introduction

As orthodontists, we strive to give all of our patients excellent occlusion. At the same time, smile esthetics is something we must also take into account. Many of our patients seek orthodontic care for esthetic reasons. They want to improve their smile and look more attractive.

Good occlusion and an esthetic smile are both related. In a study done by Havens and McNamera, it was found that the presence of a malocclusion has a negative impact on facial attractiveness. From this study, they determined that orthodontic correction of malocclusions affects the overall facial esthetics in a positive manner. Besides occlusion, many other factors affect whether or not a smile is perceived as attractive or unattractive. This includes but is not limited to the following: size of buccal corridors, smile arc, shape of anterior teeth, gingival display, upper lip line, and dental midline symmetry.

A study conducted by Schabel evaluated the correlations between the components of the Objective Grading System developed by the American Board of Orthodontics (ABO). The relationship between the occlusal outcome and smile attractiveness was evaluated. The results of the study showed that there was an extremely weak relationship found among all factors of the ABO Objective Grading System and perceived smile attractiveness. The study suggests that additional criteria might be incorporated into the assessment of overall orthodontic treatment outcomes, including variables evaluating smile esthetics.
The aim of this study is to evaluate smile esthetics of ABO board certified cases in order to determine which characteristics are associated with an attractive smile. We retrospectively analyzed the differences related to smile harmony in a random sample treated according to ABO standards. The results from this study will provide the clinician with valuable information to differentiate between the dentofacial configuration of individuals with highly attractive and less attractive smiles regardless of the presence of an excellent occlusion.
Review of Literature

Orthodontic Treatment in Relation to Smile Esthetics

Orthodontic patients not only evaluate their treatment based on their occlusion but also on the outcome of their smiles and overall enhancement in their facial appearance. It has been found that orthodontic treatment has a positive influence on facial esthetics.¹ The presence of a malocclusion has a negative impact on facial attractiveness. The value of an attractive smile can have a significant impact on one’s social interactions and work environment. Due to this, the demand for adult orthodontics has increased. The desire to straighten the teeth and improve the smile, while improving the facial appearance, were the key motivating factors.³ Many patients are dissatisfied with their present dental esthetics and want to undergo dental treatment to improve their dental appearance, resolve anterior crowding and resolve incisor protrusiveness.⁴

There are many treatment modalities to go about achieving a desirable orthodontic outcome. This may include functional appliances, extractions, space maintainers, temporary anchorage devices, etc. It has been researched that treatment modality alone has no predictable effect on the overall esthetic assessment of a smile.⁵ Subjects with ideal occlusions and Class I patients treated with or without extractions were not differentiated in smile esthetics. In another study, it was concluded that the smile esthetic scores of subjects treated with and without extraction of the four first premolars did not show any
statistically significant difference.\textsuperscript{6} This means that the simple fact of extracting teeth or not does not necessarily have a detrimental facial esthetic effect.\textsuperscript{7}

**Buccal Corridors**

The existence of buccal corridors and the perceived attractiveness of a narrow smile have been important topics of interest when judging smile esthetics. Most studies have found that orthodontists and laypeople rated smiles with small buccal corridors more attractive than those with large buccal corridors.\textsuperscript{8-10} In one study, it was found that orthodontists preferred smiles displaying the first molars compared to laypeople who preferred smiles only showing up to the second premolar.\textsuperscript{8} Significantly lower attractiveness ratings were found for smiles with excessive buccal corridors.\textsuperscript{9} It was discovered that orthodontists and orthodontic patients preferred smiles with narrow or medium buccal corridors (0\%-10\%) to those with medium broad (15\%) or broad buccal corridors (20\%-25\%).\textsuperscript{10} The studied proposed a 10\% to 15\% buccal corridor as a threshold of esthetic smile evaluations. However not all studies agree that buccal corridors play a significant role in overall facial esthetics.\textsuperscript{7,11-12} In one contraindicative study, the presence or absence of dark spaces in the buccal corridors has little influence over smile esthetics. They stated while buccal corridors must be considered in orthodontic diagnosis, there is no justification for expanding the buccal corridor to eliminate dark spaces unless they are very evident.\textsuperscript{11} A systematic review found that based on studies with actual subjects instead of computer generated images, buccal corridor size alone does not seem to affect smile attractiveness.\textsuperscript{7} Lastly, in another study, individuals with the smallest negative spaces
(buccal corridors) in proportion to smile width were compared to individuals with the largest negative spaces in proportion to smile width, and there was not statistical difference regarding the esthetic evaluation. It was concluded that the negative space did not influence the esthetic evaluation of smile photographs for the study.

Gum Display

The amount of gum showing during smiling is another important factor when evaluating the attractiveness of smiles. A “gummy” smile results from a combinations of factors such as vertical maxillary excess, increased overjet, increased overbite, a short upper lip, and a short incisor crown length. Excessive gingival display can detract from an attractive smile.

In one study, a smile with 0 mm of gingiva was considered to be the most attractive as rated by orthodontists, while a smile with 2 mm of lip coverage of the upper central incisors was considered to be the most attractive by the dental students. Another study found a statistically significant correlation between the maxillary gingival display and the esthetic score: the greater the maxillary gingival display, the lower the esthetic score. As one ages, the amount of gum display decreases. A significant decrease of 1.5 to 2 mm in maxillary incisal display at smile was found with increasing age. When individuals were asked to judge their smile attractiveness with a questionnaire, participants whose smile displayed their teeth entirely with some gingival display (2mm-4mm) perceived their smile as most esthetic. Smiles with disproportional gingival display were judged negatively and correlated with the personality characteristics of neuroticism and self-esteem.
Smile Arc

The smile arc is commonly used as a parameter to evaluate and categorize an individual’s smile. The smile arc is a virtual line that connects the incisal edges of the maxillary anterior teeth and follows the upper border of the lower lip. In a systematic review, it was concluded that the smile line is a valid tool to access the esthetic appearance of a smile. It can be applied universally as clinicians and laypersons perceive and judge it similarly.\(^\text{16}\) One study classified frontal photographs of smiling individuals and found the five smiles with the highest scores were symmetrical with an average upper lip line and a consonant smile arc.\(^\text{17}\) All five of the lowest rated smiles from the same study has a nonconsonant smile arc. Another study found that orthodontically treated patients demonstrated significantly more parallel smile arcs compared with a nontreated group.\(^\text{18}\) They found on average most subjects displayed a flat smile arc, and females showed a more parallel smile arc compared to males. Lastly in a systematic review, results showed that the smile arc did not interfere in smile attractiveness when natural smiles were on trial.\(^\text{7}\) It was concluded that smile arc alone is not able to influence smile esthetics.

Other smile characteristics

There are many studies relating to smile attractiveness that incorporate other characteristics not previously mentioned. In a study rating clinical photographs, the subjects rated with the most unattractive smiles had a significantly greater distance between the insical edge of the maxillary central incisors and the lower lip during smiling.\(^\text{19}\)
Another important factor is the coincidence of the upper midline to the facial midline. If was found that dental to facial midline discrepancies reduce dentofacial attractiveness. Discrepancies of 2 mm of more are likely to be noticed by both orthodontists and non-dental university students.\textsuperscript{20} Another study agreed with this conclusion and found that a limit of 2.2 mm can be considered acceptable for midline deviation.\textsuperscript{7} The shape and proclination of the anterior teeth also play a role in smile esthetics. It was determined from a pamphlet study that incisor shape was the key determinate in esthetic preference, and round incisors were the most esthetic.\textsuperscript{21} Both maxillary incisor labiolingual inclination and anteroposterior position play an essential role in the esthetics of the smiling profile.\textsuperscript{22}

**Summary**

It is undeniable that smile esthetics play a major role in orthodontic treatment. As it has been stated, occlusion is one important key in an attractive smile. Orthodontist must also take into account other smile characteristics to create an attractive smile. This study will help to determine what characteristics are most important in smile esthetics.
Literature Cited


Chapter 2: Manuscript

Smile Attractiveness of ABO Board Cases: A Retrospective Analysis

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Abstract

Aim: To investigate the common denominators of an esthetically pleasing smile in treated cases, which were successful upon the submission to American Board Orthodontics (ABO) clinical examination.

Material and Methods: A total of 462 successful ABO cases were examined. 90 subjects that fulfilled the inclusion criteria were included. Standardized digital smile photographs of the subjects were rated by 30 panel members including orthodontists, general dentists and parents of orthodontic patients using a numeric version of the visual analog scale (VAS). Three groups were formed using the mean esthetic score ± SD range: unattractive (n = 21), average (n = 47), and attractive (n = 22) smiles. Eleven smile characteristics were digitally measured on the photographs and were compared between the groups using one-way analysis of variance (ANOVA) and chi-square tests. Additionally, regression analyses were used to investigate the association of the smile characteristics with the esthetic score.

Results: A significant difference was found between the three groups for the comparison of smile arc relationship (p<0.001). When all the variables used in this study were entered in the regression analysis, a positive association was found (r=0.658, r square=0.434, p<0.001). Additionally, two models were defined using stepwise regression. The first model included the smile arc (r=0.478, r square=0.228, p<0.001) and the second model had both the smile arc and right gingival display/visible dentition display ratio (r=0.567, r square=0.321, p<0.001).

Conclusions: A harmonious smile arc relationship and less gingival display during a smile are significantly associated with smile attractiveness in successful ABO cases.
Introduction

The success of orthodontic treatment can be determined by various objective measures. However, society and our patients predominantly focus on the final esthetic outcome,\(^1\) which can be quite subjective to judge. Therefore, numerous clinical and experimental studies attempted to define how an esthetically pleasing smile could be achieved following orthodontic treatment. As a result, buccal corridors,\(^{2-5}\) smile arc,\(^{6,7}\) incisor protrusion\(^{1,8}\) and gingival display\(^{1,9}\) have commonly been cited as the potential characteristics that influence the esthetic outcome of an orthodontically treated case. Our current knowledge suggests that alterations in these variables directly affect the esthetic perception of the individual.

In the United States, The American Board of Orthodontists (ABO) developed the Objective Grading System (OGS)\(^10\) as a valid and reliable index to evaluate the posttreatment occlusal outcome. The components of the OGS are based on evaluations made on the dental casts and panoramic radiographs and are used in the clinical part of the board-certification process. Although board certification is not required for orthodontists to practice,\(^{11}\) it is almost a necessity today for calibration and technical acuity considering the increasing number of orthodontists in the country. Although OGS has been a great tool integrated into the clinical practice, a well-designed study by Schabel et al.\(^{12}\) demonstrated only extremely weak relationships among all factors of the OGS and smile esthetics. Furthermore, both the total score and the individual components of the index failed to predict whether the smiles were attractive or not.
Plaster models and panoramic radiographs are not of valuable information when judging complex facial features and yet the smile itself. Moreover, Ackerman et al.\textsuperscript{13} suggested that not all orthodontically well-treated patients with excellent occlusal relationships and exemplary plaster models have acceptable esthetics during smiling. Accordingly, since orthodontists in the U.S. are striving to finish their cases according to the ABO standards right from the beginning of their clinical training, additional information is required to differentiate between attractive and unattractive smiles that possess board quality occlusal outcomes. Therefore, the objective of the present study was to investigate the common denominators of an esthetically pleasing smile in treated cases, which were successful upon the submission to ABO clinical examination. The results of the study will suggest supplemental information to the clinicians when evaluating the overall treatment outcome.
Material and Methods

The study subjects were recruited from the University of XXXXXXXX Graduate Orthodontic Clinic and were all treated between the years 2001-2012. Based on a pilot study evaluating the differences between three groups of varied buccal corridor ratios, an effect size of 0.41 was estimated. Using G*Power 3.1\textsuperscript{14} statistical programme, we determined a total sample size of 69 was required to detect this effect with 85% power and significance level of p<0.05. A total of 462 successful American Board of Orthodontics cases were examined. The following criteria were used for inclusion in the study: age from 14 to 24 years, Angle Class I or II malocclusions prior to treatment with no craniofacial anomalies and missing teeth, no evident asymmetry, treated with 0.022-slot full-fixed edgewise appliances, and a complete set of records including a full frontal smile photograph. 90 subjects that fulfilled the criteria were included in the study. The total treatment times were between 1.8-2.2 years with an average of 2.01 years. The total scores of the Objective Grading System (OGS) ranged from 11 to 23 in the study sample.

All photographs were taken at a distance of 30 inches object-to-lens distance with a Canon EOS SLR digital camera (Canon USA Inc., Lake Success, NY) in JPEG file format. Adobe Photoshop CS5 (Adobe Systems Inc., San Jose, CA) was used to edit the photographs. A 2 x 3 standardized template was used to crop the images, leaving a proportionate area around the lips. Skin areas were edited to remove irregularities and/or blemishes to avoid any distraction during the evaluation process. The images were then converted to black and white and copied to slides in PowerPoint (Microsoft, Redmond, Wash) for evaluation. The
panels consisted of 10 parents, 10 general dentists, and 10 orthodontists with equal gender distribution in the groups. The ages of the panel members varied from 40 to 62 years, with a mean of 51.3. The panel members were asked to evaluate the smile attractiveness using a segmented numeric version (NRS) of the visual analog scale (VAS) in which a respondent selects a whole number (0-10 integers, 0=least attractive and 10=most attractive) that best reflects their choice. The evaluation time was 20 seconds for each slide and they were allowed to go back and revise their scores at the end.

A total of eleven characteristics (Table I) were evaluated digitally on frontal smile photographs. Image Tool for Windows version 3.00 (UTHSCSA, San Antonio, TX) was used for the measurements. A demonstration of the measurements used in this study is shown in Figure 1. Spatial measurements were calibrated by drawing a line of known length (width of the central incisors). The same examiner repeated all measurements after three to four weeks for testing intra-examiner reliability.
**Statistical Analysis**

All of the statistical tests were performed using SPSS for Mac (version 21; IBM, Armonk, NY). Pearson product-moment correlation coefficients (Pearson’s $r$) were used to determine the agreement between the panel groups. There was a significant correlation between the ratings of each possible pair of panel groups with a mean $r(88)=0.86$, $p<0.05$. Therefore, the ratings of the panels were pooled ($n=30$) for the rest of the analysis. The reproducibility of the evaluation process was evaluated by asking all panel members to reevaluate ten randomly selected images at 1-month intervals using intra-class correlation (ICC) analysis. Three groups were formed using the mean esthetic score ± SD range: unattractive ($n=21$), average ($n=47$), and attractive ($n=22$) smiles. One-way analysis of variance (ANOVA) was used to compare the numeric variables measured from the smile photos between the groups. Chi-square test was used to compare the categorical variables. Additionally, linear regression analyses were used to investigate the association of the smile characteristics with the esthetic score.
Results

The test-retest ICC between the first and second rating evaluations was 0.86 (95% CI 0.82-0.94), which indicated a high level of repeatability for the judges. Based on the calculations of the whole panel group, mean and median esthetic scores of the sample group were 6.66 and 6.61, respectively with a standard deviation (SD) of 1.02, which were used to form the study groups. Intra-examiner reliability demonstrated a near perfect agreement between the first and second measurements of the study variables (ICCs tanging between 0.92-0.99). Table II presents the descriptive statistics of the variables investigated in this study for the three groups. One-way ANOVA revealed no significant differences between the groups (Table II, Figure 2). Chi-square test demonstrated a significant difference between the three groups for the comparison of smile arc relationship (Table III, p<0.001).

When all the variables used in this study were entered in the regression analysis, a positive association was found (r=0.658, r square=0.434, p<0.001), which could only explain 43% of the esthetic score variance. Additionally, two models were defined using the stepwise technique. The first model included the smile arc (r=0.478, r square=0.228, p<0.001) and the second model had both the smile arc and right gingival display/visible dentition display ratio (r=0.567, r square=0.321, p<0.001).
Discussion

Smile is a complex feature to analyze. Since it is not a fixed concept, esthetic prediction of dynamic facial features upon the completion of the treatment can be a lot harder to judge than any other physical processes. However, clinicians require objective measures and guidance to fully be able to evaluate the outcome of the orthodontic treatment, which commonly starts with esthetic concerns.\textsuperscript{15} Although the American Board of Orthodontics (ABO)’s Objective Grading System (OGS) was developed to provide clinicians with an objective index for outcome assessment, clinical research\textsuperscript{12} in this area clearly demonstrates that OGS criteria have no evident link to the smile. It was, therefore, of interest to us to explore the distinguishing characteristics of the smiles that are perceived more attractive than others in a sample of individuals that were treated according to ABO standards.

Our panel members included dental professionals and parents of orthodontic patients. A segmented numeric version (NRS) of the visual analog scale (VAS) was preferred as the evaluation method, since high test–retest reliability was observed in both literate and illiterate individuals with the use of NRS.\textsuperscript{16,17} Our initial findings were parallel to previous research papers\textsuperscript{1,8,18,19} that reported high similarity in the ratings of the panel groups when evaluating the smile photos. Therefore, the esthetics scores of the three panel groups were pooled. Based on the ratios used in this study, individuals with attractive smiles had more maxillary teeth and less mandibular teeth, gingiva and buccal corridors showing during a posed smile. However, none of these characteristics showed significant difference between
the three groups. This is partly due to the individual variations since our sample comprised of real subjects and not computer simulated images. A recent systematic review\textsuperscript{20} revealed that studies, which used digitally altered images bring out rather conclusive results than those studies with actual patient photographs in the evaluation of smile characteristics. Moreover, the variables evaluated in this study together were only able to explain the 43% of the esthetic score variance in the sample group. It is evident from this finding that other factors also contributed to the esthetic perception of the smiles. For instance, Heravi et al.\textsuperscript{21} found that the shape of the maxillary incisors played a significant role in esthetic perception of the smile in a group of lay people regardless of sex and age. McNamara et al.\textsuperscript{8} concluded that vertical lip thickness proved to be the most influential variable in smile esthetics. It may not be possible for orthodontists to control for such variables during the course of the treatment.

Perhaps the most important characteristic affiliated with smile esthetics in our sample was the ‘smile arc’ relationship. We found that a significant number of the individuals in the attractive smiles group had consonant smile arc relationships while the majority of the individuals with unattractive smiles had non-consonant smiles. This was also supported with the finding that the smile arc was significantly correlated with the esthetic score ($r=0.478$, $r$ square=0.228, $p<0.001$) using stepwise regression analysis. In the second model defined by the same analysis, only gingival display/visible dentition ratio for the right side added up to this effect ($r=0.567$, $r$ square=0.321, $p<0.001$). Less gingival display enhanced the esthetic score. This finding is in agreement with previously published papers.\textsuperscript{1}
Although gingival display/visible dentition display and left gingival display/visible dentition display ratio measurements may equally be important, no statistical significance for these variables were demonstrated in the sample possibly due to the individual variability, e.g. slight asymmetry.

Ackerman et al.\textsuperscript{13} and Sarver\textsuperscript{6} signified the importance of smile arc, which can best be defined as the harmonious relationship between the curvature of the lower lip to the curvature of the maxillary incisor edges and the canine tips during a smile. While this relationship was significantly associated with the esthetics of the smile in experimental studies,\textsuperscript{22,23} McNamara et al.\textsuperscript{8} failed to identify a direct relationship in actual patients. However, Schabel et al.\textsuperscript{24} found that individuals with the "most unattractive" smiles had a significantly greater distance between the incisal edge of the maxillary central incisors and the lower lip during smiling, which may indicate the presence of a non-consonant smile. In our study, 81.8% of the individuals in the attractive group and only 19% of the individuals in the unattractive group had consonant smiles (p<0.001). Interestingly, the average smile group had almost an equal distribution of both the consonant and non-consonant smile arcs. Our results are contrary to the findings of Janson et al.\textsuperscript{20} who claimed that smile arc does not affect smile attractiveness in studies with actual patients.

In smile esthetics, arch form and buccal corridors have gained great interest in the last decade. Although the panel members favored less buccal corridor space in the group of attractive smiles, buccal corridor ratios did not significantly affect the esthetic perception of the posttreatment outcome in our study. It was already shown in a well-designed study\textsuperscript{28}
that orthodontists and laypeople rated smiles with small buccal corridors as significantly more attractive than those with large buccal corridors. However Maulik and Nanda\textsuperscript{29} revealed that in a group of orthodontically treated and untreated individuals, most subjects demonstrated a buccal corridor ratio of 11%. Similarly, studies\textsuperscript{2,4,7} that focused on the acceptable threshold of this variable indicated a significant decrease in the esthetic score when the buccal corridor ratios were altered more than 10%. Based on our calculations, buccal corridor ratios in all three groups evaluated in this study, on the average, are limited to 7-8%. This may explain the lack of statistical significance between the three groups of actual patients. Additionally, it was shown by Chang et al.\textsuperscript{30} among nine other smile variables buccal corridor ratios showed the least test-retest reliability in a group of adult model photographs. As argued before, in actual patients it is difficult to judge such relationships since smile discrepancies may be within a tolerable range rather than the ones that are digitally generated.\textsuperscript{20}

This study confirms the fact that in any group of subjects even with the most excellent occlusal relationships, there is individual variability—shape of the teeth, curl of the lips, and mouth expression—that would lead the smile to be perceived as esthetically pleasing or not.\textsuperscript{1} Our findings also represent the difficulty of identifying objective parameters to evaluate the esthetics of a dynamic facial trait—the smile using two-dimensional photographs of actual patients. Future studies should be planned to evaluate the smile characteristics using three-dimensional photographs and analyses to confirm the current results and to further expand our knowledge in this field.
Conclusions

Esthetic score variance in a group of subjects treated to an excellent occlusal outcome could not be fully explained with all the objective parameters used in this study. Harmonious smile arc relationship and less gingival display during a smile are significantly associated with smile attractiveness in orthodontically treated cases that were successful upon the submission to ABO clinical examination.
References


# Appendix

## Table 1. Definitions of the smile esthetics variables used in our study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Visible incisor height / Smile height ratio %</td>
<td>Visible height of the maxillary central incisor / Vertical height of the smile between upper and lower lips measured in the contact point of maxillary central incisors.</td>
</tr>
<tr>
<td>Smile arc (Consonant, non-consonant)</td>
<td>Presence of a harmonious relationship between the curvature of the lower lip to the curvature of the maxillary incisor edges and the canine tips during the smile.</td>
</tr>
<tr>
<td>Smile arc discrepancy/ Smile frame %</td>
<td>Area of mandibular teeth showing below the curvature of the maxillary incisor edges and the canine tips / Total area between upper and lower lips during the smile.</td>
</tr>
<tr>
<td>Gummy smile (Present, not present)</td>
<td>Presence of maxillary gingival tissues showing during the smile.</td>
</tr>
<tr>
<td>Gingival display / Visible dentition display %</td>
<td>Area of maxillary gingival exposure between inferior border of upper lip and marginal gingiva of maxillary teeth / Area of maxillary and mandibular teeth between the lips during the smile.</td>
</tr>
<tr>
<td>Gingival display (right) / Visible dentition display %</td>
<td>Area of maxillary gingival exposure between inferior border of upper lip and marginal gingiva of maxillary teeth on the right side / Area of maxillary and mandibular teeth between the lips during the smile.</td>
</tr>
<tr>
<td>Gingival display (left) / Visible dentition display %</td>
<td>Area of maxillary gingival exposure between inferior border of upper lip and marginal gingiva of maxillary teeth on the left side / Area of maxillary and mandibular teeth between the lips during the smile.</td>
</tr>
<tr>
<td>Visible dentition width / Intercommissure width %</td>
<td>Distance between most lateral left and right points of visible maxillary dentition during smiling / Distance between left cheilion to right cheilion during smiling.</td>
</tr>
<tr>
<td>Visible dentition display/ Smile frame %</td>
<td>Area of maxillary and mandibular teeth between the lips during the smile / Total area between upper and lower lips during the smile.</td>
</tr>
<tr>
<td>Right buccal space/ Visible dentition display %</td>
<td>Area inside the corner of the lips and lateral to the visible maxillary and mandibular dentition on the right / Area of maxillary and mandibular teeth between the lips during the smile.</td>
</tr>
<tr>
<td>Left buccal space/ Visible dentition display %</td>
<td>Area inside the corner of the lips and lateral to the visible maxillary and mandibular dentition on the left / Area of maxillary and mandibular teeth between the lips during the smile.</td>
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</tbody>
</table>
Table 2. Mean values of the smile esthetic variables in the study groups

<table>
<thead>
<tr>
<th>Variables used in our study</th>
<th>Attractive smiles n=22</th>
<th>Average smiles n=47</th>
<th>Unattractive smiles N=21</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visible incisor height / Smile height ratio %</td>
<td>78.7 12.2</td>
<td>76.0 12.2</td>
<td>72.2 9.3</td>
<td>0.21</td>
</tr>
<tr>
<td>Smile arc discrepancy/ Smile frame %</td>
<td>17.7 3.6</td>
<td>19.0 4.3</td>
<td>19.3 4.5</td>
<td>0.89</td>
</tr>
<tr>
<td>Gingival display / Visible dentition display %</td>
<td>3.8 3.4</td>
<td>7.8 5.6</td>
<td>10.7 6.2</td>
<td>0.07</td>
</tr>
<tr>
<td>Gingival display (right) / Visible dentition display %</td>
<td>1.7 1.8</td>
<td>2.9 2.6</td>
<td>4.6 3.6</td>
<td>0.77</td>
</tr>
<tr>
<td>Gingival display (left) / Visible dentition display %</td>
<td>1.7 1.6</td>
<td>2.9 2.5</td>
<td>3.7 3.2</td>
<td>0.87</td>
</tr>
<tr>
<td>Visible dentition width / Intercommissure width %</td>
<td>82.2 4.7</td>
<td>81.7 3.2</td>
<td>81.2 3.5</td>
<td>0.42</td>
</tr>
<tr>
<td>Visible dentition display/ Smile frame %</td>
<td>93.0 4.5</td>
<td>92.6 3.0</td>
<td>92.4 4.1</td>
<td>0.18</td>
</tr>
<tr>
<td>Right buccal space/ Visible dentition display %</td>
<td>2.4 0.9</td>
<td>3.6 1.1</td>
<td>4.1 1.6</td>
<td>0.88</td>
</tr>
<tr>
<td>Left buccal space/ Visible dentition display %</td>
<td>2.7 0.9</td>
<td>3.4 1.2</td>
<td>3.8 1.2</td>
<td>0.87</td>
</tr>
</tbody>
</table>
### Table 3. Distribution of categorical variables in the groups

<table>
<thead>
<tr>
<th>Variables used in our study</th>
<th>Attractive smiles (n=22)</th>
<th>Average smiles (n=47)</th>
<th>Unattractive smiles (N=21)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smile arc</td>
<td>Consonant</td>
<td>Non-consonant</td>
<td>Consonant</td>
<td>Non-consonant</td>
</tr>
<tr>
<td></td>
<td>18 (81.8%)</td>
<td>4 (18.2%)</td>
<td>21 (44.6%)</td>
<td>26 (55.4%)</td>
</tr>
<tr>
<td>Gummy smile</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>11 (50%)</td>
<td>11 (50%)</td>
<td>27 (57.4%)</td>
<td>20 (42.6%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15 (71.4%)</td>
<td>6 (28.6%)</td>
</tr>
</tbody>
</table>
Figure 1. Figure demonstrates the measurements used in our study: gingival tissue area divided by the area of maximum visible dentition.
Figure 2. Visual comparison of the mean values in the study groups.
Leslie Katherine Frels was born in Victoria, Texas on December 16, 1984, to John and Kathy Frels. Raised in Yorktown, Texas, Leslie graduated from Cuero High School in 2003. Following high school, she attended the University of Texas at Austin where she received her Bachelor of Business Administration degree in Finance. Leslie was also pre-dental at the University of Texas and graduated Cum Laude. Upon graduation from college in 2007, Leslie attended dental school at the University of Texas Health Science Center at Houston Dental Branch. She earned her Doctor of Dental Surgery degree in May of 2011. Following dental school, she began her orthodontic residency program at the University of Texas Health Science Center at Houston School of Dentistry. Upon receiving her Certificate in Orthodontics and a Masters of Science in Dentistry degree in August of 2013, Leslie will begin practicing in Houston, Texas and Victoria, Texas.
University of Texas
School of Dentistry at Houston

Master of Science in Dentistry Degree Data Sheet

Name: Leslie Frels  Degree Sought: Master of Science in Dentistry
Major: Orthodontics  Date of Graduation: August 17, 2013
Permanent Home Address: Department: Orthodontics

Exact Title of Thesis:
Smile Attractiveness of ABO Board Cases: A Retrospective Analysis

Special Field of Thesis:
Smile Esthetics

Total Number of Pages: 40  Total Number of Illustrations: 2

Previous Degrees:

<table>
<thead>
<tr>
<th>Degree</th>
<th>Name of University</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.D.S.</td>
<td>University of Texas Health Science Center at Houston Dental Branch</td>
<td>2011</td>
</tr>
<tr>
<td>B.B.A.</td>
<td>The University of Texas at Austin</td>
<td>2007</td>
</tr>
</tbody>
</table>

____________________________

Jeryl D. English, D.D.S., M.S., Co-Chairman, Thesis Committee
Sercan Akyalcin, D.D.S., Ph.D, Co-Chairman, Thesis Committee

Brief Summary of Thesis: The aim of this study was to evaluate the smile esthetics of American Board of Orthodontics (ABO) board certified cases in order to determine which characteristics are associated with an attractive smile. We retrospectively analyzed the differences related to smile harmony in a random sample treated according to ABO standards. 90 smiles were ranked on a scale of 1-5, with 5 being the most attractive, by 10 orthodontists, 10 general dentists, and 10 laypersons. The smiles were then analyzed according to different measurement. ANOVA analysis, chi-square test, and linear regression analysis were used for statistic analysis. Harmonious smile arc relationship and less gingival display during a smile are significantly associated with smile attractiveness in orthodontically treated cases that were successful upon the submission to ABO clinical examination.