Assessment of Dental Appearance Following Changes in Incisor Angulation

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Purpose: This study evaluated the assessment of attractiveness of standardized changes in incisor angulation of different tooth arrangements. ***Materials and Methods:*** Four sets of images showing the maxillary anterior teeth without lips against a black background were used for evaluation. Each set contained the original photograph, one computer-manipulated symmetric image, and four images with different standardized changes in incisor angulation (10 degrees). The judges, consisting of three groups (30 dental students, 30 medical students, 30 art students), ranked each photo set for attractiveness from 1 (most attractive) to 6 (most unattractive). ***Results:*** The mean ranking (in parentheses) showed that symmetric teeth with ideal axes (2.5) and changes in the angulation of one (2.8) or both (2.5) lateral incisors were significantly more attractive than the angulation of one (4.2) or both (4.6) central incisors. There were no differences between the groups of participants. All findings were reproducible. ***Conclusion:*** Tooth arrangements showing central incisors with ideal axes were more attractive. Slight changes in the angulation of one or both lateral incisors did not influence attractiveness negatively. *Int J Prosthodont 2004;17:150–154.*

In the last few years, esthetic dentistry has become a more and more important focus for clinicians and their patients. Ongoing efforts to develop new materials and clinical methods underline this tendency.[1–5] In this context, the importance of an attractive smile and its effect on one's image has to be emphasized.[6,7] In the absence of other information, the judgments an individual makes concerning the personal characteristics of others are influenced by dental appearance.[8]

A clearly positive effect on a patient's self-esteem and life quality could be demonstrated by using porcelain laminate veneers to correct tooth shape and color. Patients tend to feel not that their appearance has attained some ideal of beauty, but rather that it is "normalized."[9] What, though, does "normalized" mean? The dependence on ethnic origins and cultural and social influence is discussed varyingly.[10,11] Esthetic knowledge, however, consisting of an accumulation of intuitions, feelings, and sensations, can be reduced no further because absolute criteria do not exist.[1,12] Instead of universal standards of esthetics, specialized textbooks[1,13] are important references in the Western world and are widely accepted by the dental community. These textbooks often differ, however, in relevant points. For example, esthetic guidelines for anterior prosthetic rehabilitation have been developed and were summarized in a sketch presenting the most important parameters to achieve an ideal esthetic appearance.[14] This sketch has to be used with caution because it completely ignores individual variations.[12]

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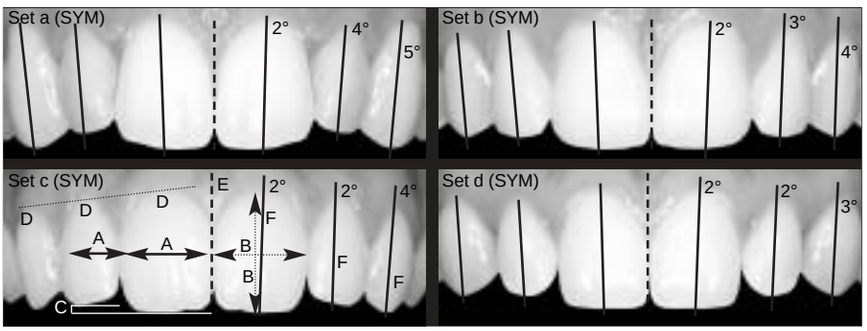

Fig 1 Symmetric images *(SYM)* of the four photo sets *(A* to *D)*. Maxillary anterior teeth and gums are presented against a black background and standardized under consideration of the following six esthetic parameters: *A* = width of lateral incisor is in golden relation to width of central incisor; *B* = incisor aspect ratio is accepted as ideal between 0.70 and 0.80; *C* = attractive incisal line of central incisors is accepted when requiring up-and-down movement (central incisor is 2 to 4 mm longer than lateral incisor); *D* = gingival level of lateral incisors should be located more coronally than that of central incisors and canines; *E* = no diastema; and *F* = angle between vertical axis of tooth arrangement and optical axis of each tooth has to be angulated 2 to 5° mesially (shown for all sets).

Therefore, it is unknown how a restoration should be designed, especially if small irregularities were part of the smile originally: Is it more attractive to integrate these asymmetries, or should they be corrected? How do minor changes in tooth angulation in anterior restorations on different teeth affect the assessment of attractiveness? So far, social attractiveness has mainly been considered from the angle of significant changes only, like prominent incisors, absence of maxillary left lateral incisor, severely crowded incisors, unilateral cleft lip,[15] various forms of symmetry,[16] or diastema.[10,17] To the best of the authors' knowledge, minor changes have never been examined. However, a few textbooks on complete dentures provide information, although they cannot of course replace studies based on scientific evidence.[18,19]

The null hypothesis in the present study was that standardized minor changes in incisor angulations (maxillary central and lateral incisors), compared with an idealized dentition, would not affect the assessment of attractiveness of tooth arrangement, independent of the location of changes. The secondary hypothesis was that there would be no differences in the judgment of art experts, dental experts, and laypersons.

Materials and Methods

Four original photographs of the smiles of two men and two women were taken for this study. The teeth were completely healthy, without any fillings or periodontal disease. The dentofacial arrangements showed at least one slight natural mesial or distal angulation concerning the maxillary central and lateral incisors. The maxillary anterior teeth (first premolar to first premolar) and gums were cut out of the photograph by image processing using Adobe Photoshop. In this "original" image, teeth and gums were shown against a black background. The four original images differed in form, size, color, and position of the teeth, and diastema, color, and form of the gums. Using digital imaging again, the original image was transformed into a symmetric "gold standard" image, which considered at least five of six main esthetic parameters (Fig 1) according to the rules of golden proportion,[12] the incisor aspect ratio (width/height) of the central incisor,[16] and the sketch of Schärer et al.[14] The angle between the vertical axis of the tooth arrangement and the optical axis of each tooth was 2 to 5 degrees mesially. Frontal axial equilibrium was accepted when the angulations of the canine and lateral and central incisors diverged a maximum of ± 2 degrees (Fig 1).

Then, the standardized incisor angulation of 10 degrees (standard deviation [SD] 1) was altered in the symmetric image, constructing four more variations (Fig 2): One lateral incisor or one central incisor was angulated, and then both lateral incisors or both central incisors were angulated symmetrically. The natural angulated tooth of the original image was used in these images, and it was subsequently determined if the angulation was performed mesially or distally (Fig 2). The same direction of inclination was used for all performed angulations in the set, thus providing the four photo sets with six variations each, two sets with mesial and two sets with distal angulations. Each variation was printed (HP DeskJet 1220C, Hewlett Packard) in color, sized 6.5 cm × 16.0 cm. A random allocation sequence of these variations was generated by casting dice, the method used for all surveys. The sequence was different for every set.

For the survey, three groups of participants were chosen: a class of 30 dental students before their final

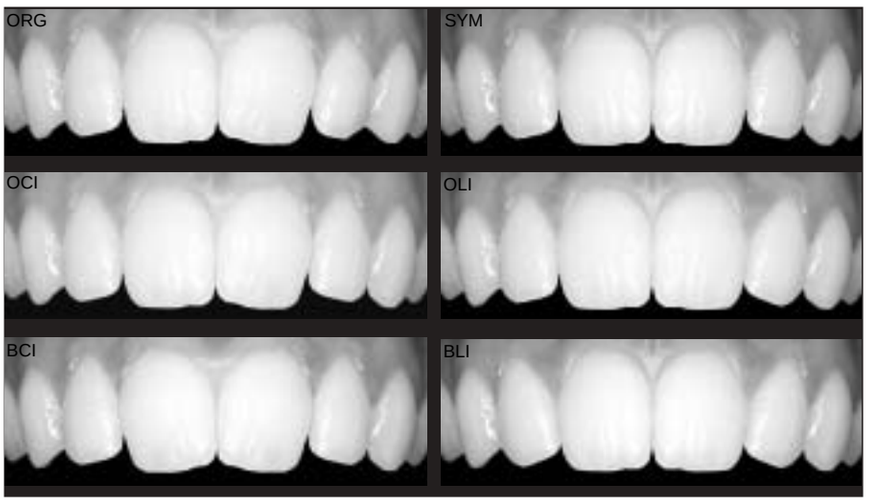

Fig 2 Six standardized variations of photo set C from Fig 1: Using digital imaging, original photograph *(ORG)* is transformed into symmetric image *(SYM).* Incisor angulation performed in the following images is Δ10° (SD 1) starting from axis of tooth (SYM). Incisors are tilted mesially, in accordance with natural irregularity (here, left central incisor) of one selected tooth from original image (ORG): One lateral incisor *(OLI)* or one central incisor *(OCI)* is angulated, both lateral incisors *(BLI)* or both central incisors *(BCI)* are angulated symmetrically, respectively.

exams (mean age 27 years, SD 2; 14 males, 16 females), 30 medical students (at least fifth semester students, mean age 23 years, SD 5; 9 males, 21 females), and 30 art students (at least sixth semester students, mean age 24 years, SD 3; 12 males, 18 females). The participants took part voluntarily and were unpaid. Only participants with normal well-being were accepted. The survey was performed in a classroom at the dental school. Appointments were made, and participants were interviewed individually. To detect a difference of 10% in the rankings, a sample size of 90 participants was calculated. Therefore, an SD of 1 and determinate alpha error of 5% and beta error of 10% were assumed. Throughout the survey, the investigator's interest in a specific dental feature was not revealed. To ensure that the participants did not differ notably from the general population in well-being, a long-established and highly reliable test, which contains 28 items, was used (Befindlichkeitsbogen, Belts Test).[20,21]

Next, the participants were asked to rank the six variations of a given photo set for appearance and attractiveness, within 1 minute. The participants were allowed to move and organize the photographs until they had achieved a definite rank order. The image that was most attractive for the participant was attributed rank 1, and the most unattractive image consequently received rank 6. Thus, every variation was assigned to a rank from 1 to 6. This procedure was repeated for all photo sets. At the first survey, the participants were not allowed to make any notes, and no information about the planned second survey was given. After 4 weeks, a second, identical survey was undertaken, making use of the same photo sets and participants.

For the statistical analysis, the data of the four photo sets were pooled in such a way that the mean rank for each variation could be used. Since the data did not violate the assumption about normality distribution (Kolmogorov-Smirnov test), a repeated-measures analysis of variance (ANOVA) with between-subjects factors was performed to determine main effects of "incisor angulations" (within-subject factor, Hotelling test), "education" (between-subject factor, *F* test), as well as their interactions (Hotelling test). Multiple pairwise comparisons of the different variations were conducted based on the paired *t* test adjusted with the Bonferroni-Holm procedure. Finally, a test of equivalence between the first and second surveys was performed.[22] All hypotheses were tested at the 95% level of confidence.

Results

In neither the first nor second survey were any significant differences found between the three student groups concerning well-being, as measured by the well-being test after von Zerssen and Koeller.[20]

The rankings of the participants were analyzed for the first and the second survey (4 weeks later). For these analyses, the data of the four photo sets were pooled in such a way that the mean rank for each variation could be used. Repeated-measures ANOVA showed a significant effect for the factor "incisor angulations" ($P \leq .001$), but no significant effect for the factor "education,"

or for the interaction between both factors ($P > .050$). Thus, the data of the three different study courses were pooled for the following analysis.

The mean ranks (in parentheses) of the first survey showed that symmetric teeth with ideal axes (2.5) and changes in the angulation of one (2.8) or both (2.5) lateral incisors were significantly ($P < .001$) different from the angulation of one (4.2) or both (4.6) central incisors (Fig 3). All findings were reproducible in the second survey. Therefore, the null hypothesis of "non-equivalent" for all images was rejected, and it could also be concluded that the first and second surveys were equivalent.

For determination of the sensitivity of the measurement instruments, the symmetric image in each set was considered the gold standard image in anterior dental esthetics. When this image was assigned to ranks 1 to 3 by the participant, sensitivity was considered positive. Sensitivity for the first survey was 77%; for the second survey it was 74%.

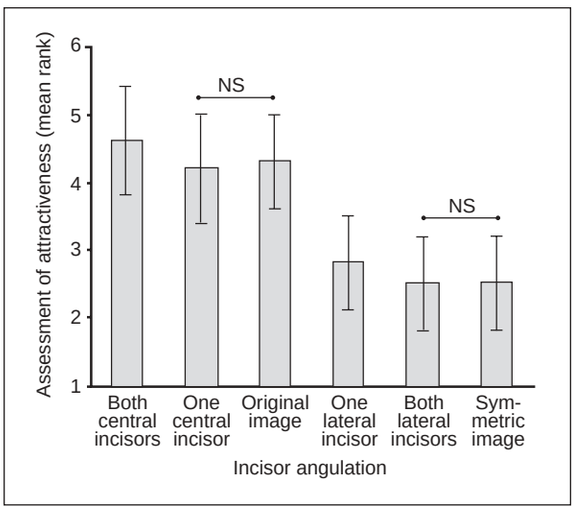

Fig 3 Assessment of attractiveness: mean ranks (from most attractive, 1, to most unattractive, 6) and SDs of different incisor angulations in first survey. The data of four photo sets and different study groups were pooled (n = 90). Values connected by lines were not statistically different (*t* test, $P > .050$).

Discussion

In the present study, three groups of participants were selected. All of them were full-time students, of roughly the same age, similar education, and social background, and normal well-being. They differed only in the factor "education": dental experts (dentistry students before final exams), dental laypersons (medical students), and art specialists (art students). Other studies form test groups of dentists, patients, and dental technicians.[10,16,17,23] These groups differed a lot more in such characteristics as age, education, and social background than our groups. Differences in their appreciation could therefore not be exclusively linked to the specific criterion "dental specialization." However, in the present study, the educational background was the only obvious difference between the three test groups. Therefore, the evaluated minor changes in anterior tooth positions were rated independent of dental expert knowledge.

The specialized dental literature describes different kinds of rating scales. Rating systems with a rank order as result[10,16,24] or visual analogue scales (VAS)[15,25,26] were often used, sometimes conducted with a semi-structured interview.[9] Because of the small esthetic differences between the six variations used in the current study, a ranking order seemed more suitable. Thus, the participants were forced to make a decision as to which version of incisor angulation they liked more than the other. This would not be possible with a VAS, where theoretically all valuations could be the same. On the other hand, from a statistical point of view, a ranking is never independent because each rank can be used only once. Since pooled mean ranks were used in our study, this was considered negligible. However, ranking scales must always be interpreted carefully because distances between ranks are not equal.

For determination of the sensitivity of the measurement instruments, the symmetric image was seen as the gold standard and reference image because it considered widely accepted criteria in anterior dental esthetics. Thus, for evaluating sensitivity, this image had to be ranked by the participants on one of the leading ranks to be valued as positive. Ranks 1 to 3 were accepted as positive because of the very small changes generated in the different images, in combination with the fact that each rank could be used only once. In addition, to prove the reliability of our instruments, a test of equivalence between the first and second surveys was performed and showed no differences.

To achieve this statistical quality, it was important to focus our study on incisor angulation, even though there are other important aspects of anterior dental esthetics, for example, age-dependent varieties of morphologies ("black hole disease," tooth-gingiva relationship, abraded dentition, or discoloration). In conformation with these limitations, the participants in the current study were also limited to an age at which the above-mentioned esthetic aspects are not primarily relevant. Also, other aspects like tooth color, tooth form, tooth size, and gingival margins[10,17,26] could not be taken into account, or better should be filtered out. Therefore, data of the four photo sets were pooled, and the mean rank for each variation was used. Thus, the influence of these characteristics and their interactions

with incisor angulation could be reduced, and the main factor "incisor angulation," standardized in all photo sets, could be highlighted.

In contrast to other studies, neither the face[10,15,25] nor the lips[26] were shown on the images. This study design was chosen because background facial attractiveness stimuli are often more influential than individual dental conditions.[15,27] Avoiding these stimuli allowed the participants to focus more on the tooth angulations. This could be one of the reasons why in the present study the factor of education (laypersons vs specialists) had no significant influence on the ranking order, whereas it played a major role in previous literature.[10,16,28]

Under the assumption that a perfect restoration should not be identifiable as artificial, but should be part of the harmony of a natural tooth arrangement, it seems adequate to relate our results to the restoration of anterior teeth or orthodontic treatment in young adults: The arrangement of teeth does not have to be perfect, according to the sketch of Schärer et al.[14] Sometimes, it might be even more attractive to integrate small irregularities to get a harmonious tooth arrangement. However, the central incisor should be restored with an ideal axis and symmetry. The angulation of one or both of the lateral incisors may be adapted slightly (≤ 10 degrees) mesially or distally to individual needs. This is underlined by others, who propose that a smile must be more symmetric nearer the midline to appear harmonious.[1]

Under the limitations of the present study—lips, mandibular teeth, and faces were eliminated, and participants were limited to a special cultural, social, and educational group—the following can be concluded. Symmetric teeth with ideal axes as well as minor changes in the mesial or distal angulation of the lateral incisors (≤ 10 degrees) had the greatest influence concerning attractive appearance. A mesial or distal angulation (10 degrees) of one or both central incisors had the most unattractive effect. These results were reproducible in a second survey, which showed stability in the esthetic ratings of participants. There were no differences in the evaluations of "dental experts," "laypersons," and "art experts."

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