Smile Characterization By US Whites, US Asian-Indian and Indian Populations

A Thesis
Presented in Partial Fulfillment of the Requirements for the Degree Master of Science in the Graduate School of The Ohio State University

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Abstract

With the expectation of high esthetic standards, dentists must understand patient perceptions and incorporate these preferences into treatment. However, little is known how cultural and ethnic difference influence esthetic perception. Objectives: To determine if culture/ethnicity affects a layperson's perception of esthetic and smile characteristics. Methods: A survey was constructed using a series of images that were digitally manipulated in almost imperceptible steps, changing one smile parameter to form a strip of images that displayed that parameter over a wide range. Data were collected on a stand-alone laptop via a customized program running within MATLAB®, which randomly displayed a single image. The participant used the mouse to adjust an on-screen slider according to displayed instructions that asked the rater to obtain their ideal or minimally acceptable image. Computer-based smile esthetic surveys based on emoticon (slider) technology allow control of variables and the possibility of obtaining continuous data. Three population groups were surveyed (total N=288): US Whites, US Asian-Indians and Indians living in India. The sample gave a power of 0.86 to detect a difference of ±1.5 mm in each variable. Raters’ evaluated images showing smile arc, buccal corridor, gingival display, vertical overlap, lateral incisal offset, maxillary midline to midface and maxillary to mandibular midline. Rater reliability was assessed using the Fleiss-Cohen weighted Kappa (Kw) statistic and corresponding 95% Confidence Interval after repeating each question in a random sequence. Choice differences due to culture/ethnicity were assessed with a multiple randomization test and adjusted p value using the step-down Bonferroni method of Holm. Results: Kw for 17 variables in all three groups ranged from 0.11 for ideal overbite to 0.64 for ideal buccal corridor space.
Overall reliability was modest. There were statistically significant differences between all 3 groups for buccal corridor space (ideal, maximum and minimum acceptable), smile arc (ideal, maximum and minimum acceptable) and maxillary to mandible midline deviation. The Asian-Indians living in the US did not significantly differ from Indians in India except for lateral to central incisal edge discrepancy, overbite-ideal, midline to face and maxillary to mandibular midline. Midline variations showed statistical differences between all three groups. **Conclusions:** Different ethnic groups made significantly different choices of the various parameters tested.
Dedicated to my family
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Vita

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Fields of Study

Major Field: Dentistry

Specialty: Prosthodontics
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Chapter 1

**Introduction**

The smile is an integral part of the face and, more generally of the whole person; it expresses beauty, age, personality and youth.¹ Today, esthetics exclusively concerns beauty and beauty has different meanings all over the world, having been changed by different cultural or social events.²

In medieval Japan noblewomen painted their teeth with a black paint- a practice called ohaguro as a sign of beauty and distinction.³ For Mursi tribal women of Southern Ethiopia wearing a lip plate is a sign of beauty, maturity and endurance. An Apanti tribal woman in Zio valley of Arunachal Pradesh in northeast India considers wearing a large wooden nose plug as a sign of beauty. For Kayan women in Burma wearing brass coils around the neck and elongating the neck is considered beautiful. For certain tribes in Amazon beauty is to carve teeth into triangular shapes as a sign of honor for young warriors. For the gypsy, beauty involves covering the teeth with gold prostheses. In Mayan civilization a means of enhancing dental beauty was to drill holes in their teeth and fill them with jade and other jewel inlays. They also filed their teeth into different shapes³. So cultural images influences our perception of attractiveness.

With increase in dental awareness and more patients demanding a high standard of quality as well as esthetics in dental treatment it becomes imperative that we understand their perception and incorporate their preferences in our treatment planning.
Comprehensive literature review and statement of the problem

About 5000 years ago Egyptian civilization marked the first sign of facial beauty displayed in their art works. They also studied different shapes, patterns and objects and found proportions existed in natural world around them. Particular harmonious effects have been attributed to certain proportions. Leonardo da Vinci’s Vitruvian Man drawing was based on correlation of ideal human proportions with geometry described. The principles behind creating an ideal smile originate from concepts developed in denture esthetics. In 1914, Williams concluded that human teeth could be classified into three principal shapes: rectangular, triangular, and ovoid. Lombardi suggested application of repeated proportion to achieve esthetic effect particularly for anterior denture teeth set up. Frush and Fisher stated the SPA factor in an effort to harmonize teeth with the patient’s gender, personality and age. This became the foundation of Prosthodontic philosophy.

Although subjective in nature but with the expectations of high esthetic standards the development of the smile should be based on as much objective criteria as possible. Until recently, however, the refereed literature had not clarified the importance of smile characteristics according to dental professionals or laymen. With several studies in the past decade in the field of Restorative dentistry and Orthodontics have demonstrated that dental professionals and laymen could identify smile characteristics. Some studies have applied computer-based technology to evaluate smile characteristics. Computer simulation appears to be an effective method to manipulate variables.
consistently with controlled presentation to the raters. It provides nearly continuous choices instead of categorical choices.

A number of variables have been suggested that influence the smile attractiveness such as buccal corridor space. Ker et al.\(^\text{17}\) found an acceptable range of 8\%-22\%, with an ideal value of 16\%, Moore et al.\(^\text{12}\) showed a range of 2\%-28\% corridor in their study, and concluded that having minimal buccal corridors is a preferred esthetic feature in both men and women, and large buccal corridors should be included in the problem list during orthodontic diagnosis and treatment planning. Martin et al.\(^\text{21}\) showed buccal corridors ranging from 0-16\%, and found that both orthodontists and laypersons favored smaller corridors. Parekh et al.\(^\text{16}\) showed that raters preferred normal or narrow buccal corridors to broad corridors. Hideki Ioi et al.\(^\text{22}\) in his study with Japanese population concluded that both the orthodontists and dental students preferred broader smiles to medium or narrow smiles.

The smile arc, which is defined as the curvature formed by an imaginary line tangent to the incisal edges of the teeth, was modified in varying degrees of curvature in relationship to the lower lip. The range of modification was from no curvature to an accentuated curvature. Tjan et al.\(^\text{23}\) examined 454 random photographs of dental and dental hygiene students, and found that 85\% had a smile arc parallel to the lower lip. Frush and Fisher\(^\text{7}\) identified a more curved “smile line” as more youthful in appearance than a flat one. Parekh et al.\(^\text{16}\), found that laypersons prefer parallel or even increased smile arcs much more than flat smile arcs, and that they strongly dislike flat smile arcs. Ker et al.\(^\text{17}\) also found a parallel smile arc to be ideal, and defined the range of acceptable values. Wong et al.\(^\text{24}\) compared the lip arc and smile arc of Caucasian and
Korean population and found statistically significant differences due to ethnicity and gender. Gingival display has been studied extensively. Peck and Peck’s descriptive study of 88 patients found a mean gingival display of 0.7 mm for females, and 0.8 mm for males. Kokich et al. found that orthodontists did not rate the attractiveness lower until there was 2 mm of gingival display, and laypersons until 4 mm was displayed. A more recent study by this group showed both orthodontists and laypersons to be sensitive to the increased gingival show at 3 mm display. Hunt et al. found the ideal to be 0 mm display. Ker et al.17 found an ideal of about -2 mm, with the acceptable range from -3.65 to 4 mm.

Proffit, Fields and Sarver characterized the value of overbite (vertical overlap) between 0-2 mm as ideal. Iyer et al. studied the casts of 100 Asian-Indian adult males (18-30 years) with normal occlusion and facial appearance and found mean incisor overbite of 3.2 mm to be “acceptable normal” in that population. In the PAR Index the overbite is rated as normal when it is less than or equal to one-third coverage of the lower incisor. Ker et al. found the ideal overbite to be 2 mm with a range of acceptability from 0.4 to 5.7 mm.

Many authors have reported that esthetic balance is upset when the maxillary midline is not coincident with the face’s midline. Frush reported maxillary midline deviations of greater than 2 mm were likely to be noticed by laypeople. Kokich et al. found laypeople did not even perceive 4 mm deviation. Rodrigues et al. showed an image with a 3 mm midline shift that was ranked the same by raters as the ideal image. Ker et al. showed a maximum tolerable value of nearly 3 mm as noted by laypeople. A maxillary to mandibular midline discrepancy alters anterior esthetics and often
determines how the posterior dentition will articulate. Ker et al.\textsuperscript{17} found a 2 mm limit to be 2 mm discrepancy to be the limit of acceptability.

Ethnic/culture differences concerning smile characteristics have not been extensively investigated in the past. There are data from a Japanese study that dealt with one aspect of smile esthetics that showed similar preferences to US raters\textsuperscript{22} No study has comprehensively examined whether differences in the ethnic background can alter the perception of smile characteristics. More clarification is needed for ideal and acceptable smile esthetics from a layperson’s perspective with different ethnicities so there is an awareness of potential unique esthetic preferences.

**Specific Aims**

The specific aim of this research was to access if the difference in demographic, cultural and ethnic background makes a difference in a layperson’s perception of esthetic and smile characteristics through digital image manipulation.

**Hypotheses:**

Ho1: There will be no difference in the perception of ideal and acceptable values of smile characteristics between Caucasian and Indian populations.

Ho2: There will be no difference in the perception of ideal and acceptable values of smile characteristics between Indians living in India and Indians living in the US.

For the purpose of this study smile characteristics include smile arc, buccal corridor, gingival display, vertical overlap, maxillary central to lateral incisal edge discrepancy, Maxillary midline to midface and maxillary to mandibular midline.
Population and Samples

The target population of this study included Caucasians of European descent living in the United States, Indians living in the US for 5 or more years and Indians living in India. Total number of participants was 288. All participants of this study were at least 18 years of age. Gender, age, ethnicity, length of the stay in US for Indian population were identified. The sample was drawn from those population subtypes located within the United States and India. All participants were English speaking and were familiar with the use of a mouse to control a computer. Those possessing a professional or related dental background were excluded from the sample.

References


28. Richmond S, Shaw WC, O’Brien KD, et al. The development of the PAR index (peer

Chapter 2

Materials and Methods

The overall goal of this study was to determine whether ethnic, cultural and demographic differences affect the rater’s perception of smile. Digital “continuous motion pictures of different smile characteristics were presented for lay raters of different cultural and ethnic background to evaluate.

Human Subjects Approval

Application for Institutional Review Board (IRB) exception, HIPAA waiver, and Waiver of written informed consent was granted by the IRB.

Model selection and Image manipulation

Initial image selection and manipulation followed the protocol of Ker et al. An extra oral photograph cropped to show only the lips, nasal tip, and labiomental fold from one male and one female orthodontically treated patient were combined with a bisected and mirrored frontal intraoral image using features of Photoshop CS2 (Adobe Systems, San Jose, Calif.) to create a gender-ambiguous composite image. Once a series of modification values was established that appeared to represent the range of visually realistic smiles, the tooth images were stored as sequences that showed gradual and incremental change in one variable. The survey was presented on a laptop computer using MATLAB R2008a (The Mathworks, Inc.; Natick, Mass). A customized mouse-operated graphical interface was developed that combined demographic data collection and survey administration. Interface elements included buttons that allowed advancing and backtracking in the survey as well as a central slider that modulated a single variable
in the displayed smile and lip curtain. Advancing to the next question saved the current slider position and associated variable level as a participant's answer to that question. Every image for each variable had a number assigned to it that was identified by the program as the choice and saved as data by image number. The images numbers were translated to values that represented the modification value of that smile characteristic. This allowed the participants’ choices to be summarized so that a median ideal and confidence interval for each variable could be established.

The target population of this study included Caucasians of European descent living in the United States, Asian-Indians living in the US for more than 5 years and Indians living in India. The raters were 288 participants (with 96 subjects per group) older than 18 years who were English speaking, familiar with the use of a mouse to control a computer and had no association with the dental profession. Caucasian participants were recruited at a central campus facility. Asian-Indians living in the US for 5 or more years were recruited using posters displayed at religious gathering points. Indians living in India were recruited using a poster displayed in the patient reception area of an Indian dental college. The respective institutions granted permission for the survey. The raters were first provided with a script to briefly explain the study and then had questions answered. Participants voluntarily consented to participation and to answer demographic questions, including gender, ethnicity and length of stay in the US.

The smile characteristics measured were smile arc, buccal corridor, gingival display, vertical overlap, maxillary central to lateral incisal edge discrepancy, maxillary midline to midface and maxillary to mandibular midline. Of the 7 variables, 5 (buccal corridor fill, smile arc, maxillary gingival display, incisal edge discrepancy and overbite)
had 3 questions associated with them: choose the ideal image, upper limit and lower limit. The other 2 had only 1 question: acceptable deviation from 0, because the ideal was defined as no deviation. These were maxillary midline to face and maxillary to mandibular midline discrepancy. Each variable was repeated twice to assess rater reliability. The ratersevaluated a total of 34 images. Each image was presented in a random order with one of two statements: – "Please move the slider to select the image you find to be most ideal"; or "Please move the slider to select the first image that you find unattractive." It took most participants 10-15 minutes to complete the survey. Each participant in the US was compensated with a $10 gift card and those in India with 100 rupees in cash.

Data were presented, collected and analyzed on a personal laptop computer. Series number only cataloged subjects; no personally identifying information (such as name, address, or SSN) was collected. There were no links between subject and data. Data were backed up after each session in which surveys were administered. Any hard copies of the data were locked in cabinetry within the academic Division.

Variables

The following were the 7 independent variables that were included as defined by Ker et al.:

Buccal Corridor Space – The buccal corridor is defined by the amount of dark space displayed between the facial surfaces of the posterior teeth and the corner of the mouth. Buccal corridor spaces were manipulated by altering the amount of black space between the lip commissure and the most buccal tooth in the smile by moving the posterior teeth medially or laterally. Images showed variations of about 0.18 mm for this
Smile Arc – The smile arc, which is defined as the curvature formed by an imaginary line tangent to the incisal edges of the teeth, was modified in varying degrees of curvature in relationship to the lower lip. The range of modification was from no curvature to an accentuated curvature.

Gingival Display – Gingival display is defined as the amount of gingival show above the maxillary central incisor crowns and below the center of the upper lip. Gingival display on smile was approached by modifying the skeletal position of the dental arches in 0.18 mm increments.

Lateral Incisor Step – This variable evaluated the difference between the incisal edges of the maxillary central and lateral incisors and was assessed by moving the entire lateral incisor tooth up or down in 0.18 mm increments.

Overbite – The overbite, defined as the projection of the maxillary anterior teeth over the mandibular in the normal occlusal position of the jaws, was modified by incrementally altering the mandibular layer of the photograph image in the vertical dimension. The vertical movement of the mandibular layer produced an increased or decreased overbite. The layer was moved incrementally in 0.18 mm increments.

Maxillary Midline to Face – The maxillary midline to face is considered to be ideal when the maxillary midline is coincident with the philtrum. The maxillary midline was moved to the left of the face in 0.18 mm increments. The right and left buccal corridor was maintained throughout the movement of the dentition.

Maxillary to Mandibular Midline Discrepancy – While maintaining the maxillary
the mandibular dentition was moved to the left in 0.18 mm increments. The right and left buccal corridor was maintained throughout the movement of the mandibular dentition. A maxillary to mandibular midline discrepancy alters anterior esthetics and often determine how posterior dentition will fit together.

The dependent variable was the ethnic background of the participants: They were divided into 3 groups:

Group 1: Caucasians of European descent living in the United States (US Whites)

Group 2: Persons of Indian descent living in the United States for 5 or more years (US Asian-Indians)

Group 3: Persons of Indian descent living in India (Indians)

**Statistical Analysis**

A power analysis was performed in order to determine the sample size. Of the dependent variables in this study, overbite was reported by Ker et al.\textsuperscript{17} to have the highest variance, so it was used to determine the sample size. With a non-directional alpha risk of 0.05 and assuming a standard deviation of 3.5, a sample size of 87 subjects was needed in order to detect a difference of ± 1.5 mm with a power of 0.86. Ten percent was added to this sample size in case nonparametric analysis would be needed. As a result, the final sample size per group was 96 subjects. Since there were 3 groups a total of 288 participants were required.

**Reliability**

Rater’s reliability for each variable was accessed by means of Fleiss-Cohen weighted Kappa (Kw) statistic and corresponding 95% Confidence Interval.
Gender Differences

Gender differences were assessed non-parametrically with the randomization test due to skewing of the data. As no differences were found between male and female raters, their data were combined for further statistical analysis.

Differences between ethnic groups

Comparison for different ethnic group for cultural differences was done using Multiple randomization test. Step-down Bonferroni method of Holm was used to adjust the p-values. The level of significance was set at a p value of <0.05 for all analyses.

Reference

Chapter 3

Manuscript

Smile Characterization By US Whites, US Asian-Indian and Indian Populations

Abstract

With demand for high esthetic standards, dentists must understand patient perception and incorporate preferences into treatment. However, little is known how cultural and ethnic difference influence esthetic perception. Objectives: Determine if differences in demographic, cultural and ethnic background affect a layperson's perception of esthetic and smile characteristics. Methods: Survey constructed using a series of images that were digitally manipulated in almost imperceptible steps, changing one smile parameter to form a strip of images that displayed that parameter over a wide range. Data were collected on a standalone laptop via a customized program running within MATLAB®, which randomly displayed a single image and allowed the participant to use the mouse to adjust an on-screen slider according to displayed instructions, e.g. ideal or acceptable. Computer-based smile esthetic surveys based on emoticon (slider) technology allow control of variables and the possibility of obtaining continuous data. Population surveyed (N=288): US Caucasians, US Asian-Indians and Indians living in India. Power of 0.86 to detect a difference of ±1.5 mm. Raters evaluated images showing smile arc, buccal corridor, gingival display, vertical overlap, lateral incisal offset, maxillary midline to midface and maxillary to mandibular midline. Rater reliability was assessed using the Fleiss-Cohen weighted Kappa (Kw) statistic and corresponding 95% Confidence Interval after randomly repeating each question. Choice differences due to ethnicity were assessed with multiple randomization test and adjusted
p value using step-down Bonferroni method of Holm (alpha=0.05). **Results:** Kw for 17 variables in all three groups ranged from 0.11 for ideal overbite to 0.64 for ideal buccal corridor space. Overall reliability was fair to moderate. There were statistically significant differences between all 3 groups (Caucasians and Indians living in US and India) for buccal corridor space (ideal, maximum and minimum acceptable), smile arc (ideal, maximum and minimum acceptable) and maxillary to mandible midline deviation. The Indians living in US did not significantly differ from Indians in India except for lateral to central incisal edge discrepancy, overbite-ideal, midline to face and maxillary to mandibular midline. Midline variations showed statistical differences between all three groups. **Conclusions:** Different ethnic groups made significantly different choices of the various parameters tested. Some of these choices did not significantly change due to relocation.
Introduction

The importance of dentofacial attractiveness to the psychosocial well being of an individual has been well established\textsuperscript{1, 2}. The entire concept of dentistry has changed dramatically over the past three decades, moving out of the classic era of extraction and reparative dentistry to a new age of esthetic and cosmetic dentistry\textsuperscript{3}. Esthetics, more than any area of dentistry is based on individual perception.

Patient may have a different perception of beauty from the dentist or the generally accepted set of ideal norms. Since the ultimate success of the treatment depends upon the patient’s acceptance of the esthetics it is worthwhile to look into their subjective judgment and include their preferences into treatment planning.

A smile can have different meanings in several cultures and social environments\textsuperscript{4}. Numerous factors such as demographic, racial, ethnic and cultural differences may play a significant role in perception of facial esthetics. Cultural influences are a product of a person’s environment. Cultural esthetic values are defined by factors such as attitudes of a community, economics, dental IQ and general esthetic values\textsuperscript{5}. Influences on smile design based on culture can be subtle or dominating, depending on the individual and their culture. There are accepted norms that guide a dentist when creating an esthetically pleasing smile. However, despite these norms, the preferences of the patient and their own perception of their smile must be given careful consideration\textsuperscript{5}.

No study has comprehensively examined whether differences in the ethnic background can alter the perception of smile characteristics. More clarification is needed for ideal and acceptable smile esthetics from a layperson’s perspective with different
ethnicities so there is an awareness of potential unique esthetic preferences. The purpose of this research was to assess if different ethnic backgrounds make a difference in layperson’s perception of the ideal and the acceptable range of several important smile characteristics measured in the context of lower face.

Methods and Materials

This study was reviewed and approved by the Institutional Review Board of the university and granted a waiver of written informed consent.

Initial image selection and manipulation followed the protocol of Ker et al\textsuperscript{6}. An extra oral photograph cropped to show only the lips, nasal tip, and labiomental fold from one male and one female orthodontically treated patient were combined with a bisected and mirrored frontal intraoral image using features of Photoshop CS2 (Adobe Systems, San Jose, Calif.) to create a gender-ambiguous composite image. Once a series of modification values was established that appeared to represent the range of visually realistic smiles, the tooth images were stored as sequences that showed gradual and incremental change in one variable. The survey was presented on a laptop computer using MATLAB R2008a (The Mathworks, Inc.; Natick, Mass). A customized mouse-operated graphical interface was developed that combined demographic data collection and survey administration. The participants’ choices according to the image number were translated into values that were summarized so that a median ideal value for each variable was established.

The target population of this study included Caucasians of European descent living in the United States, Asian-Indians living in the US for more than 5 years and Indians living in India. The raters were 288 participants (with 96 subjects per group).
older than 18 years who were English speaking, familiar with the use of a mouse to control a computer and had no association with the dental profession. Caucasian participants were recruited at a central campus facility. Asian-Indians living in the US for 5 or more years, were recruited using posters displayed at religious gathering points. Indians living in India were recruited using a poster displayed in the patient reception area of an Indian dental college. The respective institutions granted permission for the survey. The raters were first provided with a script to briefly explain the study and then had questions answered. Participants voluntarily consented to participation and to answer demographic questions, including gender, ethnicity and length of stay in the US.

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**Variables**

The following were the 7 independent variables that were included as defined by Ker et al.⁶:

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**Smile Arc** – The smile arc, which is defined as the curvature formed by an imaginary line tangent to the incisal edges of the teeth, was modified in varying degrees of curvature in relationship to the lower lip. The range of modification was from no curvature to an accentuated curvature.

**Gingival Display** – Gingival display is defined as the amount of gingival show above the maxillary central incisor crowns and below the center of the upper lip. Gingival display on smile was approached by modifying the skeletal position of the dental arches in 0.18 mm increments.

**Lateral Incisor Step** – This variable evaluated the difference between the incisal edges of the maxillary central and lateral incisors and was assessed by moving the entire lateral incisor tooth up or down in 0.18 mm increments.

**Overbite** – The overbite, defined, as the projection of the maxillary anterior teeth over the mandibular in the normal occlusal position of the jaws, was modified by
incrementally altering the mandibular layer of the photograph image in the vertical
dimension. The vertical movement of the mandibular layer produced an increased or
decreased overbite. The layer was moved incrementally in 0.18 mm increments.

Maxillary Midline to Face – The maxillary midline to face is considered to be ideal
when the maxillary midline is coincident with the philtrum. The maxillary midline was
moved to the left of the face in 0.18 mm increments. The right and left buccal corridor
was maintained throughout the movement of the dentition.

Maxillary to Mandibular Midline Discrepancy – While maintaining the maxillary
midline, the mandibular dentition was moved to the left in 0.18 mm increments. The
right and left buccal corridor was maintained throughout the movement of the mandibular
dentition. A maxillary to mandibular midline discrepancy alters anterior esthetics and
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divided into 3 groups:

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Statistical Analysis

A power analysis was performed in order to determine the sample size. Of the
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of 0.05 and assuming a standard deviation of 3.5, a sample size of 87 subjects was needed in order to detect a difference of ± 1.5 mm with a power of 0.86. Ten percent was added to this sample size in case nonparametric analysis would be needed. As a result, the final sample size per group was 96 subjects. Since there were 3 groups a total of 288 participants were required. Rater’s reliability for each variable was accessed by means of Fleiss-Cohen weighted Kappa (Kw) statistic and corresponding 95% Confidence Interval. Sex differences were assessed non-parametrically with the randomization test due to skewing of the data. As no differences were found between male and female raters, their data was combined for further statistical analysis. Comparison for different ethnic group for cultural differences was done using multiple randomization tests. The step-down Bonferroni method of Holm was used to adjust the pvalues. The level of significance was set at an alpha value of <0.05 for all analyses.

**Results**

The total sample surveyed was 288 comprising equal number of raters in the three groups: US Whites: 96, US Asian-Indians: 96, and Indians living in India: 96. All the respondents completed the survey.

**Rater demographics:** There were 138 female (48%) and 150 male raters (52%). Group 1 (US Whites) had a mean age of 32 years with a range of 20-56 years. Group 2 (US Asian-Indian) had a mean age of 39 years with a range from 24-72 years. Group 3 (Indians living in India) mean age was 44 years with a range of 19-68 years. For Group 2 the mean for the years of residency in US was 10 years with a range from 5-26 years. There were no statistically significant differences between the ratings for male and female raters.
**Reliability:** Kw for the 17 variables in all three groups ranged from 0.11 for ideal overbite to 0.64 for ideal buccal corridor space (Table 1). This would be considered fair to modest reliability 18, 19.

**Ethnic effects on rater preferences (Table 2):** The ideal and the threshold of acceptability are reported for each smile characteristic using medians. There were statistically significant differences between Caucasians and Indians living in India for buccal corridor space (ideal, maximum and minimum acceptable), smile arc (ideal, maximum and minimum acceptable), gingival display minimum deviation and maxillary midline to midface. There were statistically significant differences between Caucasians and Indians living in the US for minimum gingival display and minimum lateral step up. The Indians living in the US did not significantly differ from Indians in India except for lateral to central incisal edge discrepancy, overbite-ideal, and midline to face and maxillary to mandibular midline. The summary statistics for the 3 groups for various smile characteristics are included in Figures 1 through 7.

**Discussion**

The overall reliability was modest with slight to fair for Indians living in the United States, fair to moderate for Caucasians and Indians living in India 18, 19. Reliability was less when compared to Ker et al. 6 where coefficients ranged from 0.34 to 0.88. We have no immediate explanation for this.

Our data reject the stated null hypothesis that ethnic background makes no difference in layperson’s perception of smile characteristics. Our data demonstrated statistically significant differences between ethnic/cultural groups (Caucasians and
Indians living in the US). However, there were fewer differences between the groups where one segment had been relocated.

No differences were found between male and female raters. This is consistent with Ker et al.’s\textsuperscript{6} findings, as well as Martin et al.\textsuperscript{7}, Dunn et al.\textsuperscript{8}, and Moore et al.\textsuperscript{9} With no differences between male and female raters, the data were combined for further analysis.

The ethnic differences for various smile characteristics between Caucasians and Asian-Indian were statistically significant for buccal corridor, smile arc, minimum gingival display, ideal lateral step-up and maxillary to mandibular midline. Caucasians preferred broad smile, increase smile arc, greater ideal gingival display, less overbite and less midline deviations as compared to Indians living in India.

Due to the power of this study, it is possible to show very small statistically significant differences that may not be clinically significant. With the exception of buccal corridor space and minimal smile arc, the differences between the Caucasians and the Indians living in the US could be considered to be not clinically significant. None of the comparisons that were statistically significant between the Indians in the US and Indians in India rose to the 1 mm level. Therefore, they were clinically insignificant.

Comparing Caucasians to Ker et al.\textsuperscript{6} for buccal corridor space, the maximum acceptable limit seems to be similar but ideal and minimum values were almost double. This difference was unexpected. Possible explanation could be when Ker et al.\textsuperscript{6} did their study in 2008, there has been an increase in the access to the electronic mass media such as facebook, twitter, myspace, World Wide Web, TV, movies that people are now seeing different and broader images of beauty.
Caucasians and Asian-Indians living in America preferred greater ideal gingival display than Indians in India. They also preferred less tooth coverage by the lips when smiling. The mean maximum tolerable value for gingival display for both Caucasians and Indians living in India was the same about 3.42mm. This upper limit was close to Ker et al.’s study that reported the upper limit at 3.6mm. Kokich et al. found 4mm to be an acceptable upper limit. The ideal of 2mm tooth coverage and 4mm of minimum tooth coverage reported by Ker et al. was not the same as for our study. Our study showed all three groups preferred some gingival display (less than 1 mm) with Indians in India preferring less than Caucasians and Asian-Indians living in US.

The mean ideal lateral step-up for all three groups was the same at 1.8mm. The maximum and minimum limit of acceptability was very similar in all three groups. The ideal and upper limit was similar to Ker et al. with a difference of only 0.4 and 0.3mm respectively.

Indians in India preferred a deep overbite as compared to Caucasians and Indians in US. This finding may be related to the orthodontic profile of the majority Indian population having a skeletal Class II pattern. Iyer et al. studied the casts of 100 Indian male adults (18 to 30 years) with normal occlusion and facial appearance and found a mean incisor overbite of 3.2 mm with a standard deviation of 1.65 and a range of 0.0 to 7.5mm. They considered this to be “acceptable normal”.

The mean limit of acceptability for maxillary midline deviation from the facial midline was found to be 0.9 mm for Caucasians, 1.44mm for Indians in the US and 1.62 mm for Indians in India. Ker et al. showed the deviation to be 2.9 mm for maximum acceptability. Frush reported a maxillary midline discrepancy of greater than 2 mm was
likely to be noticed by laypeople. However, Kokich et al.\textsuperscript{10} found laypeople did not even perceive a 4 mm deviation.

The allowable discrepancy between maxillary and mandibular midline deviation was found to be more for Indians in India as compared to Indians in the US or Caucasians that allowed the least. Comparing it to Ker et al’s\textsuperscript{6} data, raters in our study seemed to be more exacting.

The ethnic groups chosen for comparison were Caucasians of European decent and Asians of Indian decent. Within the Asian-Indian group comparison was done between person of Indian origin living in US for 5 or more years and those living in India. This was done to see if assimilation into a different culture affects the perception of the layperson. Among various factors that affect assimilation into a culture like socioeconomic status, spatial concentration, language attainment, and intermarriage\textsuperscript{13}; Domenico de Palo et al.\textsuperscript{14} recognizes the length of stay in the host country represents a key factor for the purpose of assessing migrants’ integration. They distinguish four groups of immigrants, as a function of the time they have spent in the receiving country: less than 5 years, between 6 and 15 years, between 15 and 25 years, and more than 25 years. They found that migrants’ social relations tend to increase with their length of stay in the host country. The percentage of “socializers” rises from 62.3% for immigrants that have been in the host country for less than 5 years to 70% for those who have been there for more than 15 years. The correlation flattens out however for migrants that has been in the receiving country for a very long time (more than 25 years)\textsuperscript{14}. So for our study minimum of 5 years of stay in US was considered as an inclusion criterion.

The first Asian Indians or Indian Americans arrived in America as early as the
middle of the nineteenth century. By the end of the nineteenth century, about 2,000 Indians, most of them Sikhs (a religious minority from India's Punjab region), settled on the west coast of the United States, having come in search of economic opportunity\textsuperscript{15}. According to the 2000 census the number of Asian-Indians in US is close to 1.7 million\textsuperscript{16} and is considered to be the fastest growing community in the US\textsuperscript{17}. So this study gives useful information to dentists treating patients belonging to different ethnicity to incorporate their preferences into treatment planning.

The Indians living in the US did not significantly differ from Indians in India except for lateral to central incisal edge discrepancy, overbite-ideal, and midline to face and maxillary to mandibular midline. Relocation did not appear to make large differences. Finding few differences in smile perception between Indians living in US and in India does not seem surprising because the US Asian-Indians surveyed were mainly first generation immigrants or were on an H1B visa (temporary stay for work purposes) who were born in India. Although permeated into many segments of American economy and society most of them seem to have still retained their traditional values and culture.

**Limitations of the Study**

1. Respondents in India were mainly upper middle class who were fluent in speaking and understanding English and were familiar with the computer. This may not be a good representation of the entire cross-section of population.

2. Asian Indian raters living in the United States were mainly immigrants who were born and raised in India.

3. The skin tone of the lower face image that the raters surveyed was kept the same for
all three groups to limit the confounding variable.

**Future Studies**

Future studies may be carried out to compare smile and esthetic perception of other ethnic groups such as African-Americans, Hispanics, East Asians, Native Americans and Arab-Americans.

**Conclusions**

There were significant differences in the perception of smile esthetics between Caucasians and Indians living in India and Indians living in the United States. Ethnic/cultural differences effected the perceptions of smile esthetics and should be a consideration in treatment planning.

There were minimal differences in the perception of smile esthetics between Indians living in United States and Indians living in India. Relocation did not appear to make large differences.

Rater gender did not effect the perception of smile.

**References**


Acknowledgements

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Bibliography


Legend

Table 1. Reliability of measures

Table 2. Multiple randomization tests and Step-down Bonferroni method of Holm

Figure 1. A, Maximum BC; B, Ideal BC and C, Minimum BC

Figure 2. A, Maximum smile arc; B, Ideal and C, Minimum smile arc

Figure 3. A, Maximum gingival display; B, Ideal GD and C, Minimum GD

Figure 4. A, Maximum LS; B, Ideal LS, C, Minimum LS

Figure 5. A, Maximum overbite; B, Ideal overbite and C, Minimum overbite

Figure 6. U midline to face maximum deviation

Figure 7. U to L midline deviation
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\( ^1 \) Fleiss-Cohen weighted kappa coefficient

| \( < 0 \) | No agreement |
| 0.0 — 0.20 | Slight agreement |
| 0.21 — 0.40 | Fair agreement |
| 0.41 — 0.60 | Moderate agreement |
| 0.61 — 0.80 | Substantial agreement |
| 0.81 — 1.00 | Almost perfect agreement |
Table 2. Multiple randomization tests and Step-down Bonferroni method of Holm (X 51)

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<td>2.52</td>
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<td>1.08</td>
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<td>Ind. Ind</td>
<td>US Whites</td>
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<td></td>
<td>7.92$^{ab}$</td>
<td>8.28$^b$</td>
<td>7.38$^a$</td>
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<td>22.77%</td>
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<td></td>
</tr>
<tr>
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<tr>
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<td>4.50$^{cd}$</td>
<td>4.86$^d$</td>
<td>3.06$^c$</td>
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<td>13.3%</td>
<td>8.4%</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td><strong>Minimum Tolerable Value</strong></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>2.34$^f$</td>
<td>1.98$^f$</td>
<td>1.35$^e$</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>6.4%</td>
<td>5.4%</td>
<td>3.7%</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Same lowercase superscript letters in the columns denote ethnic groups that do not differ significantly (p>.05)

**Figure 1. Buccal Corridor in millimeters**

A, Maximum BC; B, Ideal BC and C, Minimum BC
<table>
<thead>
<tr>
<th>Variable</th>
<th>Average Depiction</th>
<th>US. Ind</th>
<th>Ind. Ind</th>
<th>US Whites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Tolerable Value</td>
<td></td>
<td>16.00(^{ab})</td>
<td>17.00(^{b})</td>
<td>15.00(^{a})</td>
</tr>
<tr>
<td>Ideal</td>
<td></td>
<td>8.00(^{d})</td>
<td>8.00(^{d})</td>
<td>5.00(^{c})</td>
</tr>
<tr>
<td>Minimum Tolerable Value</td>
<td></td>
<td>3.00(^{f})</td>
<td>3.00(^{f})</td>
<td>2.00(^{e})</td>
</tr>
</tbody>
</table>

Same lowercase superscript letters in the columns denote ethnic groups that do not differ significantly (p>.05)

**Figure 2. Smile Arc**

A. Maximum smile arc; B. Ideal and C. Minimum smile arc
<table>
<thead>
<tr>
<th>Variable</th>
<th>Average Depiction</th>
<th>US. Ind</th>
<th>Ind. Ind</th>
<th>US Whites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Tolerable Value</td>
<td></td>
<td>-3.06\textsuperscript{a}</td>
<td>-3.42\textsuperscript{a}</td>
<td>-3.42\textsuperscript{a}</td>
</tr>
<tr>
<td>Ideal</td>
<td></td>
<td>-0.72\textsuperscript{b}</td>
<td>-0.54\textsuperscript{b}</td>
<td>-0.72\textsuperscript{b}</td>
</tr>
<tr>
<td>Minimum Tolerable Value</td>
<td></td>
<td>2.70\textsuperscript{d}</td>
<td>2.88\textsuperscript{d}</td>
<td>2.34\textsuperscript{c}</td>
</tr>
</tbody>
</table>

Same lowercase superscript letters in the columns denote ethnic groups that do not differ significantly (p > .05)

**Figure 3. Gingival Display in millimeters**

A, Maximum; B, Ideal GD and C, Minimum GD
<table>
<thead>
<tr>
<th>Variable</th>
<th>Average Depiction</th>
<th>US. Ind</th>
<th>Ind. Ind</th>
<th>US Whites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Tolerable Value</td>
<td></td>
<td>2.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.52&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ideal</td>
<td></td>
<td>1.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.80&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Minimum Tolerable Value</td>
<td></td>
<td>0.72&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.45&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.54&lt;sup&gt;c,d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Same lowercase superscript letters in the columns denote ethnic groups that do not differ significantly (p>.05)

**Figure 4. Lateral Step-up (Central to lateral incisal edge discrepancy) in millimeters**

A. Maximum LS; B. Ideal LS, C. Minimum LS
<table>
<thead>
<tr>
<th>Variable</th>
<th>Average Depiction</th>
<th>US. Ind</th>
<th>Ind. Ind</th>
<th>US Whites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Tolerable Value</td>
<td></td>
<td>7.56&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.92&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ideal</td>
<td></td>
<td>5.58&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.48&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.94&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Minimum Tolerable Value</td>
<td></td>
<td>3.60&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.60&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.96&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Same lowercase superscript letters in the columns denote ethnic groups that do not differ significantly (p>0.05)

**Figure 5. Overbite (vertical Overlap) in millimeters**

A, Maximum; B, Ideal overbite and C, Minimum overbite
<table>
<thead>
<tr>
<th>Variable</th>
<th>Average Depiction</th>
<th>US. Ind</th>
<th>Ind. Ind</th>
<th>US Whites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Tolerable Value</td>
<td></td>
<td>1.44\textsuperscript{b}</td>
<td>1.62\textsuperscript{c}</td>
<td>0.90\textsuperscript{a}</td>
</tr>
<tr>
<td>Ideal</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Same lowercase superscript letters in the columns denote ethnic groups that do not differ significantly (p>.05)

**Figure 6. Maxillary Midline to Midface in millimeters**

A. Maximum deviation, B. Ideal
<table>
<thead>
<tr>
<th>Variable</th>
<th>Average Depiction</th>
<th>US. Ind</th>
<th>Ind. Ind</th>
<th>US Whites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Tolerable Value</td>
<td></td>
<td>1.80\textsuperscript{b}</td>
<td>2.16\textsuperscript{c}</td>
<td>1.26\textsuperscript{a}</td>
</tr>
<tr>
<td>Ideal</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Same lowercase superscript letters in the columns denote ethnic groups that do not differ significantly (p>.05)

**Figure 7. Maxillary To Mandibular Midline in millimeters**

A. Maximum deviation, B. Ideal