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Education

University of Maryland School of Dentistry (Baltimore, MD)
- M.S. in Biomedical Sciences and Certificate in Orthodontics, Expected June 2016
- Chief Resident, 2015-2016

University of Connecticut School of Dental Medicine (Farmington, CT)
- D.M.D., May 2013

University of Connecticut (Storrs, CT)
- Molecular and Cell Biology and Physiology and Neurobiology
- B.S., May 2009

Certifications and Professional Memberships

- State of New Jersey Dental License, February 2016
- State of Pennsylvania Dental License, March 2015
- Laser certification course, October 2014
- Invisalign certificate, October 2013
- American Association of Orthodontists
- Maryland State Society of Orthodontists

Research Experience

University of Maryland School of Dentistry, Department of Orthodontics, 2013-present
Principle Investigator: Bhoomika Ahuja, BDS, MS
- ***Project Title:*** *Perception of Optimal Profile in South Asians Among Orthodontists and Laypeople*

University of Connecticut School of Dental Medicine, Department of Craniofacial Sciences, 2010-2012
Principle Investigator: Mina Mina, DMD, PhD
- ***Project Title:*** *Insights into mechanisms by which FGF2 inhibits mineralization and odontoblast differentiation*
- AADR San Diego, 2011
    - Poster presentation: *A. Nellissery, K.B. Sagomonyonts, A. Pollard, and M. Mina. Effects of FGF2 on 17IA4 cell line. University of Connecticut Health Center, Farmington, CT, UMRS747, Université Paris-Descartes, Paris, France*
- Hinman Research Conference, University of Tennessee, 2011

University of Connecticut School of Dental Medicine, Department of Behavioral Sciences and Community Health, 2009-2011
Principle Investigator: Edward Thibodeau DMD, PhD

- ***Project title:*** *Pre-requisite courses at US and Canadian Dental Schools*
- ADEA, Washington DC 2010
    - Poster presentation: *Nellissery A, Thibodeau E. Pre-requisite Course Requirements at United States and Canadian Dental Schools.*

Related Education and Professional Experience

ADEA Gies Foundation/AADR Academic Dental Careers Fellow, June 2011-June 2012

- *One of ten students selected nationally to participate in a year-long fellowship experience including teaching opportunities, research, faculty mentorship, and presentation of a summary report at two national ADEA meetings.*

Global Health Externship - Comayagua, Honduras, April 2011

- *Participated on a team of 32 dental students, dentists, hygienists, and assistants. We provided restorative dentistry and oral surgery services pro bono to 500 people over a five day period.*

Kaplan Test Prep and Admissions Instructor, 2009-2011

- *Taught classes on various strategies to score well on the Dental Admission Test*

Awards and Grants

Journal of Clinical Orthodontics Eugene L. Gottlieb Student of the Year Finalist - 2016

- *Selected as one of twelve students nationally based on clinical case presentation, academic achievement, and faculty recommendation*

Mid-Atlantic Society of Orthodontists Case Shoot-Out 2nd Place – Wilmington, DE, 2015

- *Selected to represent University of Maryland at regional meeting and received award for achieving ABO standard finish for a complex orthodontic case*

Dr. Meyer Eggnatz Memorial Scholarship Endowment – University of Maryland School of Dentistry, 2015

- *Awarded to one postgraduate student recognizing excellence in clinical care*

Omicron Kappa Upsilon - University of Connecticut Chapter, 2013

- *Selected as part of the top 10% of the graduating dental class to this national dental honor society*

Academic Excellence Award - University of Connecticut School of Dental Medicine, 2013

- *Awarded to the graduating student with the best academic performance over the four year curriculum*

Dean's Research Award - University of Connecticut School of Dental Medicine, 2011

- *Awarded to the most outstanding scientific presentation during student research day*

NIH-NIDCR Bloc Travel Grant – American Association of Dental Research, San Diego, 2011

- *Funding awarded to support travel to the AADR meeting*

ADEA Student Poster Award - Washington DC, 2010
- *Awarded to the top three student poster presentations at the ADEA national meeting*

Charles A. Vernale Scholarship - Connecticut State Dental Association, 2010
- *Recognizes academic success and leadership in the 2nd year of the dental curriculum*

Leadership Scholarship - University of Connecticut, Storrs, CT, 2005-2009
- *Covers the cost of tuition over the 4 year undergraduate curriculum*

Special Interests

Reading, yoga, running, baking, traveling

ABSTRACT

The goal of this research is to investigate the factors that affect perception of South Asian profile esthetics among laypersons and orthodontists. A comparative ranking of South Asian profiles and Caucasian profile silhouettes was studied. Scores based on esthetic preference were provided by survey respondents on a numerical scale. Results were analyzed for statistical significance using regression models. Individual profiles were analyzed using cephalometric tracings, and twelve hard and soft tissue cephalometric variables were selected to be studied.

Due to the growing diversity of the orthodontic patient pool, orthodontists should be aware of the specific factors that influence esthetics across cultures. Esthetic normal values developed for Caucasians may not necessarily apply to the South Asian patient. Our results show that a convex profile is found to be more esthetically acceptable in a South Asian population than in a Caucasian population among both orthodontists and laypersons. Specifically, it was found that correlations between esthetic scores with interincisal angle and lower lip protrusion were statistically different between Caucasian and South Asian profiles. When treating patients of South Asian backgrounds, it may be possible to maintain slightly greater than average lower lip protrusion or slightly greater than average dental protrusion without negatively impacting profile esthetics among this ethnic group. Knowledge of these trends can help orthodontists with treatment decisions among this group of patients.

A Study of Factors Affecting Perception of South Asian Profile Esthetics Among Orthodontists and Laypersons

Anu Nellissery, DMD

Dissertation Submitted to the Faculty of the Graduate School of the
University of Maryland, Baltimore in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
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ACKNOWLEDGEMENTS

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Chapter 1: INTRODUCTION

The perception of beauty is an individual preference influenced by individual personalities, cultural beliefs, and contemporary media influences. Psychologists have identified universal, biological aspects of beauty that are shaped by cultural and historical influences (Perrett et al, 1999). Cultures differ, however, in what is considered beautiful and within cultures people differ in what they find to be beautiful. Ideals of beauty have evolved over time as a result of several factors including modern media and globalization.

The Role of the Orthodontist in Improving Esthetics:

Defining beauty in a constantly changing society has become more and more important as health professionals have increased their ability and skill to change faces. It is widely accepted that orthodontic tooth movement can alter esthetics. As orthodontists have tried to describe beauty, they have also attempted to predict how orthodontic tooth movement affects existing facial balance. Orthodontists have suggested that occlusion and facial beauty are interdependent. It is theorized that when teeth are straightened and the occlusion is corrected to osseous cephalometric standards, optimal facial esthetics will result. Although person's ability to recognize a beautiful face is innate, translating this into defined treatment goals can be challenging.

Several pioneers in the field of orthodontics have evaluated preferences for facial esthetics. Edward Angle, the forefather of modern orthodontics, first commented on the

role of the teeth in facial esthetics. He stated that the dental apparatus must be in harmony and balance with all body structures. The features of each individual, including the forehead, nose, chin, and lips, must have a harmonious relationship with the mouth. He further stated "in order to achieve the creation of harmonious relations of facial features, the teeth must be positioned ideally to achieve normal occlusion (Angle, 1907)."

Others following Angle have studied the relationship of facial esthetics to occlusion. With the introduction of cephalometric radiography, these individuals developed several analyses to quantitate esthetic profiles. Downs used hard tissue measurements to analyze profile imbalance to differentiate between good and poor dentofacial profiles (Downs 1956).

Orthodontic Measurements of Esthetics:

As a standard, lateral cephalometric head films are used to diagnose, treatment plan and predict hard tissue and soft tissue responses to orthodontic treatment. Orthodontists have established standard cephalometric values to aid in quantifying ideal esthetics. It is thought that when teeth are straightened to these established cephalometric standards, optimal facial esthetics will result. However, the assumption that bite correction based on cephalometric standards leads to correct facial esthetics is not always true, and in some cases, may result in less than desirable facial profile outcomes. This may be attributed to the fact that the soft tissue covering the teeth and bone varies greatly to influence facial harmony.

Soft tissue measurements, including several lines and angles, have also been outlined to aid in quantifying facial esthetics. Holdaway developed the H-angle, which is formed by a line tangent to the chin and upper lip with the line connecting Nasion to Basion (N-B line). This measurement is dictated by skeletal convexity in an individual's face. According to Holdaway, ideal esthetics exist when this angle is between 7°-15° (Holdaway, 1983). Another soft tissue measurement is the E-line, described by Ricketts, which establishes the ideal position of the lower lip. Rickets states that the lower lip should be two millimeters behind the E-line, which is a line drawn from the tip of the nose to the end of the chin (Ricketts, 1960) as shown in Figure 1.1. The upper lip should fall just slightly posterior to the lower lip. Merrifield describes the Z-angle (Figure 1.2), which is formed by the intersection of Frankfort plane and a profile line formed by touching the chin and the most procumbent lip. On average, esthetic faces usually have a Z-angle of ~80 as an adult and ~78 as a child 11 to 15 years of age (Merrifield, 1966).

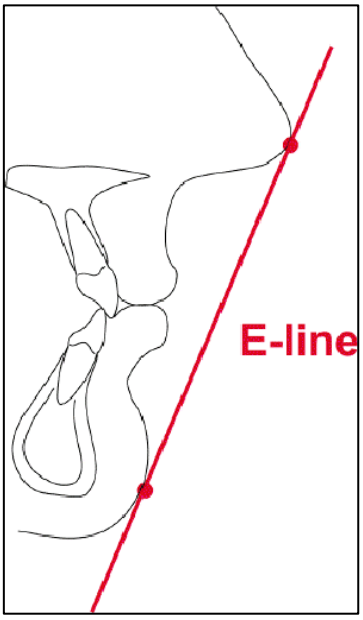


Figure 1.1 – Rickett's E-line Diagram

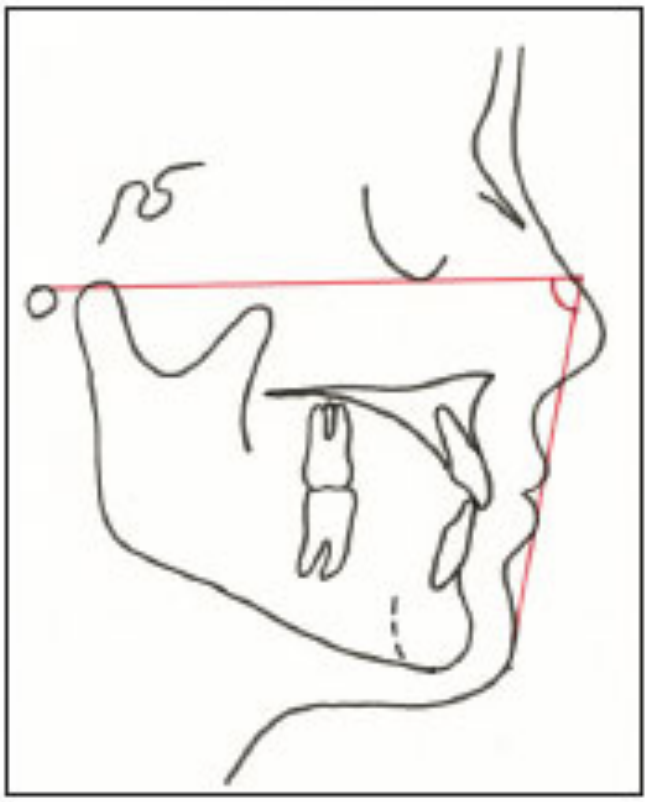


Figure 1.2. – Merrifield's Z-angle

Scheideman and Bell studied the anteroposterior points on the soft tissue profile below the nose. They dropped a true vertical plane from the natural head position through subnasale and measured lip and chin relationships to this line (Schneideman, 1980). They also assessed vertical soft tissue relationships of the face, and established ideal facial proportions for the lower facial third.

Worms discussed lip assessment for proportionality, interlabial gap, lower face height, upper lip length, and lower lip length (Worms, 1980). Legan and Burstone also described another measure to study soft tissue esthetics through the angle of facial convexity. This is the angle formed by the soft tissue glabella, subnasale, and soft tissue pogonion

(Burstone, 1967 and Legan, 1980) as shown in Figure 1.2. Lip protrusion or retrusion was measured as the perpendicular linear distance from subnasale-pogonion plane to the most prominent point on the upper and lower lips. They reported that the upper lip was positioned in front of Sn-Pg line by 3.5 mm, and the lower lip is in front of the line by 2.2 mm as shown in Figure 1.3 (Burstone, 1967 and Legan, 1980).

The zero meridian line, developed by Gonzales-Ulloa is a line perpendicular to the Frankfort horizontal, passing through the nasion soft tissue to measure the position of the chin. The chin should lie on this line or just short of it. The Steiner esthetic plane and the Reidel plane have also been used to establish esthetic standards (Steiner 1959 and Reidel 1957). The Powell analysis, which is made up of the nasofrontal angle, nasofacial angle, nasomental angle, and mentocervical angle, has been developed to give insight into an ideal facial profile.

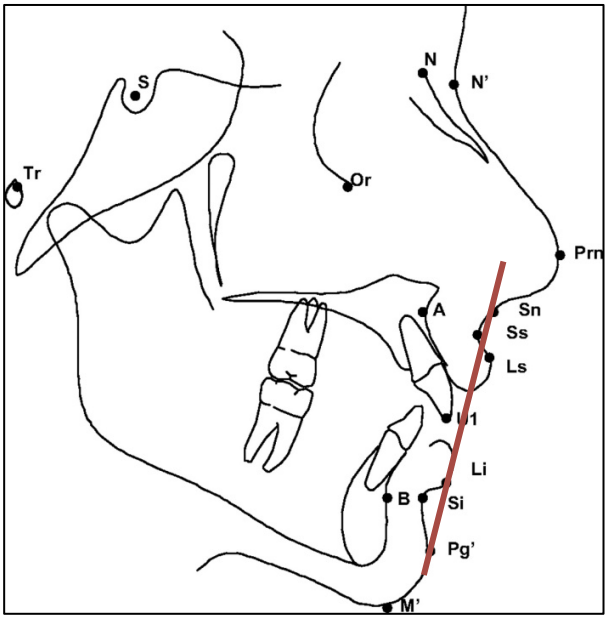


Figure 1.3 – Burstone's Sn-Pg Reference Plane

Tooth Movement and the Facial Profile:

Since it is widely accepted that tooth movement can alter facial esthetics, the facial profile is considered by orthodontists when diagnosing and treatment planning. Angle related esthetics to the position of the maxillary incisor, while Tweed relied on the position of the mandibular incisor and its relationship to the basal bone. These two different perspectives have contributed to different treatment philosophies. The use of the cephalometric films has helped orthodontists in applying esthetic considerations to treatment plans through measurements of hard tissues. Cephalometric normative values have been established to guide diagnosis and tooth movement decisions (Downs 1956, Steiner 1959, Ricketts 1982). These values and analyses have been used as the standard because of the ease of obtaining, measuring, and comparing (through superimposition) these hard tissue structures, and the belief that treating the face to these established values results in an esthetically pleasing facial form. Clinical exam in addition to cephalometric normal values should be used to develop comprehensive treatment decisions.

An orthodontist's objective should be to achieve ideal facial harmony; however, the expectations of the patient must be considered because ideals of esthetic profiles may vary. Professionals and laypersons perceive profile esthetics differently (6-10). As a result, the orthodontist may have some uncertainty in evaluating the profile of the patient and deciding on a treatment plan that will satisfy the patient. Previous studies have shown that esthetic judgments vary between observers as well (Hall 2000), and that racial background can effect perception of ideal profile esthetics.

In a landmark study by Foster (1973), silhouettes of profiles were presented to groups of general dentists, laypersons of Caucasian, Asian, and African American backgrounds, orthodontists, and art students. These silhouettes were altered only in the region of the lips, with a range of successive retrusion or protrusion created. All silhouettes stemmed from a Caucasian profile. It was found that there were similarities in esthetic ideals between these groups. Fuller profiles were preferred among younger profiles overall. Flatter profiles were preferred for males among laypersons than among orthodontists. Overall, when comparing Caucasian profiles of differing lip protrusion, lay persons and orthodontists exhibited similar esthetic preferences.

A similar study by Kerr and colleagues published in the British Journal of Orthodontics (1990) showed profiles of different silhouettes to laypersons, general dentists, orthodontists, and patients of children undergoing orthodontic treatment. The groups were asked to evaluate profile esthetics. This study based their analysis on dental relationships in addition to skeletal relationships and reported that all groups found class II and class III malocclusions to be less attractive than class I malocclusion. Laypersons were less critical than general dentists and orthodontists.

Esthetics in Non-Caucasian Populations:

In addition to studies done on Caucasian patients, several others investigated whether the mean cephalometric averages of American Caucasians created by Downs were applicable to other ethnic groups. Cotton, Takano, and Wong applied Downs' analysis respectively

to African Americans, Japanese Americans, and Chinese Americans respectively. All came to the conclusion that Downs' mean values were not applicable to their respective groups (Cotton 1951).

To further expand upon these studies, Hall et al. utilized a similar research design and showed profiles of both African American and Caucasian profiles to groups of Caucasian and African American laypersons and Caucasian and African American orthodontists (Hall 2000). All raters preferred the African American profiles to have a fuller profile than the Caucasian profiles, but differences existed within the groups for amount of fullness preferred. This study further demonstrated that in fact there are esthetic preferences for different racial groups, which are relatively consistent among orthodontists and laypersons. When the cephalometric and soft tissue measurements of these profiles were analyzed, it was found that the attractive African American profiles exhibited different cephalometric and soft tissue numerical values than the Caucasian profiles. As a result, it was concluded that orthodontists should treat African American patients to a slightly different esthetic standard than Caucasian patients.

With the knowledge that attractiveness varies for different ethnic groups, cephalometric and soft tissue normal values have been established for African American patients, Asian (Chan 1972) patients, and Caucasian patients. Many of these norms have been created based on the average measurements found among populations of untreated profiles within these ethnic groups. In this study, we aim to identify an esthetic treatment ideal for patients of South Asian decent based on preferences indicated by a survey panel.

Esthetics Among South Asian Populations:

Studies have shown that there are differences between the faces of South Asians and Caucasians, as well as ethnic variation among other races. In an early study Kotak applied Downs normal values to Indian Gujarati girls with an age range of fourteen to seventeen years old. He concluded that the mean facial angle was reduced in this population, which indicated that there was a more posterior position of the mandible in relation to the cranium when compared with Downs values (Kotak 1964).

Nanda and Nanda (1969) performed the earliest and most comprehensive study of South Asian cephalometric measurements. In the study, they evaluated lateral cephalograms of fifty individuals ages seventeen to twenty-five from the Indian subcontinent. Common landmarks were identified and evaluated. Their study sample showed increased facial convexity and more protrusive dentitions when compared with Downs cephalometric standards for Caucasians. The mean values of facial angle, A-B plane to facial plane angle, and mandibular plane angle were all found to be less than those presented by Downs, while the mean angle of convexity was greater. When compared with other ethnic groups, it was found that the angle of convexity was greater in African Americans, Chinese Americans and Japanese Americans than in Indian Americans. This indicated that the maxillary part of the face is protrusive in these three ethnic groups when compared to Caucasians and Indians. Nanda also reports that the mean mandibular plane angle is smaller in the Indian group than in the other ethnic groups. Lower incisor to mandibular plane angle in this same sample is shown to be ten degrees greater than the

mean value established by other investigators on the Caucasian normal values. A comparison of different ethnic groups revealed that the dental pattern of the Indian sample is significantly more protrusive in relation to the American Caucasian group. These values demonstrate a difference in both skeletal and dental mean values among this Indian population when compared to the Caucasian normal values. Nanda concluded that while treating Indian patients, "a slight protrusion of teeth in comparison with Caucasian standards will be optimum for their features."

In a study of South Indian cephalometric normal values, Kalha et al (2006) determined significant differences between male and female South Indian subjects, including that males had increased soft tissue thickness than women and more acute nasolabial angles. Male faces were longer (nasion to menton). Women had greater maxillary incisor exposure and interlabial gap. In addition, the study compared findings of the soft tissue cephalometric analysis (STCA) from both sexes to those published for Caucasian normal values. It was noted that the Indian sample had more proclination of the maxillary and mandibular incisors and shorter mean facial length when compared to a Caucasian sample.

In a study of dentofacially normal Caucasian subjects, Scheideman et al (1980) reported that the maxillary lip was slightly anterior, the mandibular lip was just posterior, and the chin was 4.5 to 4.2 mm posterior to the vertical reference line. However, in this study of South Indian normal subjects, both the upper and lower lips were anterior and the chin was posterior to this reference line in both sexes. Also, the mean lower third face

projections as shown by soft-tissue A-point and B-point pogonion were higher than those of the samples in the STCA (Arnett 1993) suggesting more retrusive lower faces in the Indian population.

The mean midface projections to the true vertical line from orbital rim, cheekbone, and subpupil were higher than the values of the STCA (Arnett 1993), which suggests more retruded and deep-set midface structures in the Indian sample. These findings together suggest that both sexes in the Indian population had more retruded midface structures and also more proclined maxillary and mandibular incisors compared with the samples of the STCA developed by Arnett in 1993.

Current literature has quantified normal values for particular ethnic groups. Many authors suggest that separate norms for distinctive populations are necessary. Do these differences in measured norms have clinical relevance? Are esthetic expectations different for South Asians than Caucasians? Should orthodontists consider different esthetic goals when treating South Asian patients?

Since the soft tissues largely determine the limitations of orthodontic treatment, from the perspectives of function and stability, as well as esthetics, the orthodontist must plan treatment within the patient's limits of soft tissue adaptation and soft tissue contours. The present study aims to determine the most esthetic soft tissue contour for the South Asian patient in order to aid the orthodontist in making treatment decisions for this population.

Treatment strategies need to consider changing patient preferences as esthetic values evolve and the population seeking orthodontic treatment becomes more diverse.

Specific Aims for this study:

Specific Aim 1: Determine esthetic preference of orthodontists and layperson's for South Asian profiles as compared to Caucasian profiles.

a) Determine if there is a difference in average rating of profile esthetics between laypeople and orthodontists regardless of ethnicity of profile shown.
b) Is there a difference in ratings for South Asian profiles between orthodontists and laypersons? Is there a difference in ratings for Caucasian profiles between orthodontists and laypersons?
c) Determine if South Asian profiles are rated differently from Caucasian profiles among orthodontists. Determine if South Asian profiles are rated differently from Caucasian profiles among lay people.

Specific Aim 2: Further analyze all profiles through cephalometric analysis. Determine if there is a difference between Caucasians and South Asians with respect to the hard tissue cephalometric measurements that are associated with attractiveness.

Specific Aim 3: Determine if soft tissue landmarks (mentolabial sulcus, upper lip protrusion, lower lip protrusion) differ among attractive profiles of South Asians and Caucasians.

Chapter 2: MATERIALS AND METHODS

Subject data and evaluators:

Profile photographs were selected from the University of Maryland Orthodontic Clinic and from private practices in Los Angeles, CA. The sample consisted of twenty profiles total, ten of Caucasian descent, and ten of South Asian descent. The criteria used for selection included: a wide range of profiles; no history of previous orthodontic treatment; a range of skeletal relationships without any severe vertical, transverse, or anteroposterior discrepancies; and no history of facial trauma or facial surgery. Profiles of adults age 18-55 were used.

Silhouette profile images were created from the photographs as shown in Figure 2.1. Silhouettes were used to eliminate the influence of skin color, hair texture, and other characteristics that might have biased judgment. These twenty silhouette profile images were compiled into a paper survey that was sent to twenty orthodontists and twenty-four laypersons. The profiles were clearly identified as South Asian or Caucasian. The Institutional Review Board approved this study as non-human subjects research.

The evaluators were asked to assess the profiles and to rate each profile on a numerical scale from 0-10. The scale used indicated a 0 = unaesthetic and 10 = esthetic. The orthodontists' and laypersons' responses were tabulated to determine the response of each group of raters for the South Asian and Caucasian samples.

0 1 2 3 4 5 6 7 8 9 10

Figure 2.1 Example of silhouette and rating scale utilized in survey

Prior to rating the profiles, each rater was asked to fill out a demographics survey. Raters were asked to report the following on the survey: gender, age, ethnicity, years practicing orthodontics.

Using the cephalometric radiographs of each profile, twelve cephalometric measurements were extracted and documented per profile. The Maryland Analysis was used, which combines cephalometric information about each profile from the Steiner, Tweed, Ricketts' and McNamara analysis'. Six soft tissue measurements and six hard tissue measurements were explored. The six soft tissue cephalometric measurements were Upper Lip Protrusion, Lower Lip Protrusion, Upper Lip to E-Line, Lower Lip to ELine,

Nasolabial Angle and Mentolabial Sulcus depth. The six hard tissue measurements investigated were Y-axis, the angle between A point, Nasion, and B point (ANB), the Wits appraisal, lower incisor to mandibular plane angle (IMPA), upper incisor to nasion-A point angle (U1-NA) and Interincisal Angle. Regression plots were made to examine the associations and correlation coefficients were determined. Statistical analyses were performed for each aim.

Aim 1a: Determine if there is a difference in average rating of profile esthetics between laypeople and orthodontists regardless of ethnicity of profile shown.

Informal Analysis: To address this aim informally, the mean ratings of the lay person's to the mean ratings of the orthodontists were compared. Since each rater will have rated the same patients, differences seen will be unbiased.

Formal Analysis: Statistically, a paired t-test was performed. Standard deviation was calculated. The corresponding p-value provides a measure of the strength of evidence against the hypothesis that there is no difference between the average ratings of orthodontists and lay people.

Aim 1b: Is there a difference in ratings for South Asian profiles between orthodontists and laypersons? Is there a difference in ratings for Caucasian profiles between orthodontists and laypersons?

Informal Analysis and Formal Analyses. These questions can be assessed by performing the analyses described above for Aim 1a separately for South Asian profiles and Caucasian profiles.

Aim 1c: Determine if South Asian profiles are rated differently from Caucasian profiles among orthodontists. Determine if South Asian profiles are rated differently from Caucasian profiles among lay people.

Informal Analysis. Compare the mean rating of the Caucasians to the mean rating of the South Asians among all raters, and separately among orthodontist and lay people ratings.

Formal Analysis. These questions were assessed by performing a two-sample t-test and calculating the corresponding standard deviation. This was done overall, and separately for orthodontists and lay people.

Aim 2: Determine if there is a difference between Caucasians and South Asians with respect to the cephalometric measurements that are associated with attractiveness.

Informal Analysis. This was done by calculating the mean rating for each profile and determining the degree to which the mean is correlated with specified cephalometric measures. This was done overall, and separately for South Asian and Caucasian profiles. The correlations were informally compared.

Formal Analysis. To formally test this hypothesis, six hard tissue cephalometric measurements were compared to average profile esthetic scores using a linear regression model. A correlation coefficient was determined for each subgroup and overall for both

groups. The associated p-values were interpreted as the strength of evidence against the hypothesis that the associations do not differ.

Specific Aim 3: Determine if soft tissue landmarks (nasolabial angle, lip protrusion, lip thickness) differ among attractive profiles of South Asians and Caucasians.

Formal Analysis. To formally test this hypothesis, six soft tissue landmarks were identified and a linear regression model was applied. A correlation coefficient was determined for each subgroup and overall. The associated p-values were interpreted as the strength of evidence against the hypothesis that the associations do not differ.

Chapter 3: RESULTS

I. Survey Results

Twenty orthodontists asked to participate in the study, which was comprised of sixteen men and four women. Twenty four laypersons participated in the study, eighteen females and six males. Twenty profiles were included in the survey (see Appendix 1), ten of South Asians (five males and five females), and ten of Caucasians (five males and five females).

The average rating across all profiles was higher for orthodontists than laypersons. Overall, the average score given by orthodontists was 5.18 and the average score given overall by laypersons was 4.23 as shown in Table 1. The difference in average scores shows that for most profiles surveyed, orthodontists rated profile esthetics higher than laypersons (Figure 1). This difference in ratings between orthodontists and laypersons was found to be statistically significant using a paired t-test with a p-value of 0.0012 as shown in Table 2.

Furthermore, orthodontists generally rated both subgroups of South Asian and Caucasian profiles higher than laypersons rated those same profiles. Orthodontists rated South Asian profiles with an average score of 5.70, and laypersons rated this same group of profiles with an average score of 4.69. Orthodontists rated Caucasian profiles with an average score of 4.66, and laypersons rated this same group of profiles with an average score of 3.76. A paired t-test of the average scores in each subgroup resulted in a p-value of 0.0087 for South Asian profiles, and p-value of 0.0600 for Caucasian profiles as shown in

Table 2. This analysis shows that there is a statistically significant difference in ratings for South Asian profiles between orthodontists and laypersons, and that there is a statistically significant difference in ratings for Caucasian profiles between orthodontists and laypersons.

Average scores for South Asians and Caucasians were also compared. Overall, South Asian profiles received an average score of 5.12 and Caucasian profiles received an average score of 4.15. This difference was studied using a two-sample t-test and was not found to be statistically significant (p-value 0.111). When comparing laypersons' average ratings for subgroups of South Asians (4.69) and Caucasians (3.76), it was found that the average scores were not statistically significant. When comparing orthodontists' average ratings for subgroups of South Asians (5.70) and Caucasians (4.66), it was also found that the average scores were not statistically significant (Table 3).

Profile #2 (SAF) was rated as the most attractive South Asian profile with an average attractiveness rating of 8.24. The most attractive Caucasian profile was Profile #11 (CF) with an average attractiveness rating of 6.60.

II. Association between survey results and features

All of the profiles surveyed were analyzed using cephalometric tracings. The cephalometric values corresponding to the twelve measurements studied for each profile are shown in Table 4.

Regression analysis was performed for each hard and soft tissue cephalometric variable for both subgroups of South Asian and Caucasian profiles and overall as shown in Table 5. Of the hard tissue cephalometric values studied, ANB showed the strongest correlation to profile esthetic score, with an overall correlation coefficient of -0.4478. Interestingly, for Caucasian profiles, a negative correlation was found (-0.6792), indicating that as ANB values decreased, profile esthetic scores increased. This finding is expected since a lower ANB angle translates to a smaller difference jaw positions relative to the anterior-posterior plane, which results in a more harmonious facial profile. However, in South Asian profiles, very minimal correlation was noted between ANB and profile esthetic score (0.0059), indicating that larger discrepancies in upper and lower jaw position are found to be esthetically acceptable within this population.

When evaluating the effect of soft tissue cephalometric measurements on profile esthetic scores, it is found that the strongest correlation is with cephalometric values for mentolabial sulcus (0.5004) and upper lip protrusion (0.4883) overall. Both p-values indicated that the relationship between these two features and profile esthetic score was statistically significant. Similar to ANB, a negative correlation was found among Caucasian esthetic profile scores and upper lip protrusion (-0.7658), whereas almost no correlation was found between South Asian profile scores and upper lip protrusion (0.0970). This finding indicates that as upper lip protrusion decreases, esthetic scores increase among a Caucasian population, but upper lip protrusion has little effect on esthetic scores among a South Asian population.

Analysis was also performed to compare correlation coefficients between South Asian and Caucasian profiles. Differences in correlation coefficients for South Asians and Caucasians were statistically significant for two cephalometric variables, both interincisal angle (p-value of 0.045) and lower lip protrusion (p-value of 0.031). For interincisal angle, among Caucasian profiles the correlation coefficient was 0.6025 and for South Asians, the correlation coefficient was 0.2382. For lower lip protrusion, the correlation coefficient was -0.6239 for Caucasian profiles and 0.1353 for South Asian profiles.

For other soft tissue measurements such as upper lip to E-line, lower lip to E-line, lower lip protrusion, and nasolabial angle, a relationship to perception of attractiveness could not be assumed. Also, the same relationship to attractiveness could not be assumed for the hard tissue features of each profile such as IMPA, U1-NA, Y-axis, Wits, and Interincisal Angle as indicated by the corresponding correlation coefficients.

Profile #	Orthodontists Average Score	Laypersons Average Score	Difference in Scores
Profile 1 (SAF)	7.11	5.54	1.57
Profile 2 (SAF)	8.72	7.88	0.85
Profile 3 (SAM)	5.50	5.46	0.04
Profile 4 (SAM)	4.94	3.58	1.36
Profile 5 (SAF)	4.61	3.67	0.94
Profile 6 (SAF)	3.83	4.92	-1.08
Profile 7 (SAM)	6.83	5.25	1.58
Profile 8 (SAF)	4.50	3.58	0.92
Profile 9 (SAM)	4.67	2.29	2.38
Profile 10 (SAF)	6.28	4.71	1.57
Profile 11 (CF)	7.56	5.88	1.68
Profile 12 (CM)	4.89	3.38	1.51
Profile 13 (CF)	4.22	4.88	-0.65
Profile 14 (CM)	6.44	3.33	3.11
Profile 15 (CM)	3.11	2.58	0.53
Profile 16 (CF)	4.11	3.29	0.82
Profile 17 (CF)	6.22	4.17	2.06
Profile 18 (CM)	3.28	3.42	-0.14
Profile 19 (CF)	3.00	4.25	-1.25
Profile 20 (CM)	3.78	2.46	1.32

Table 1: Average scores for profiles presented in the survey. SA= South Asian, C= Caucasian, M= Male, F= Female

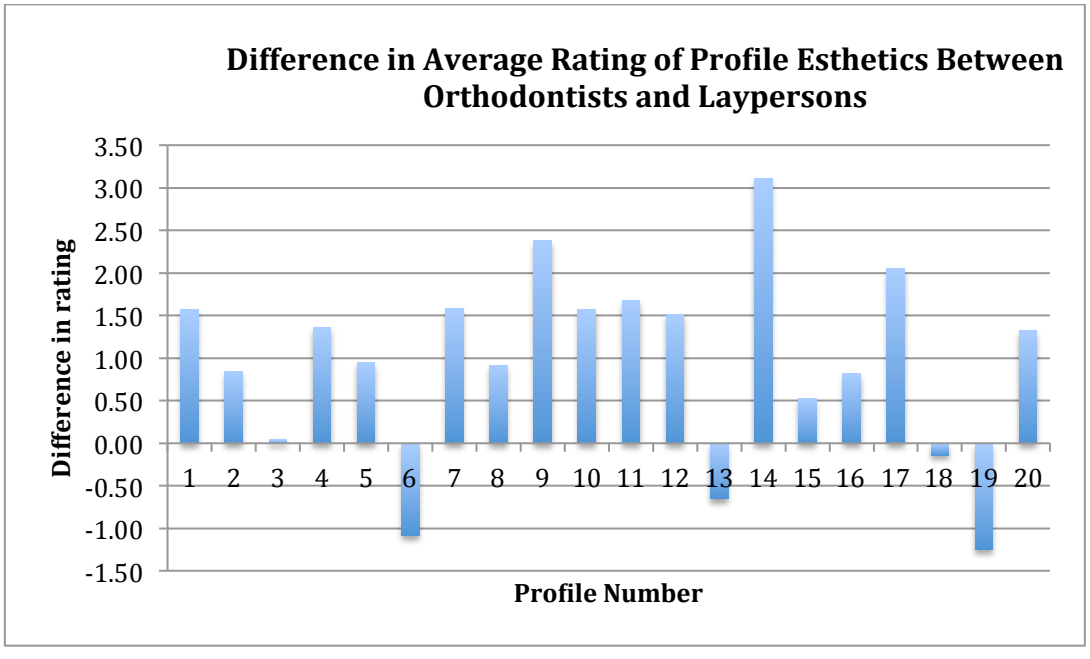


Figure 3.1. Difference in average profile rating between orthodontists and laypersons

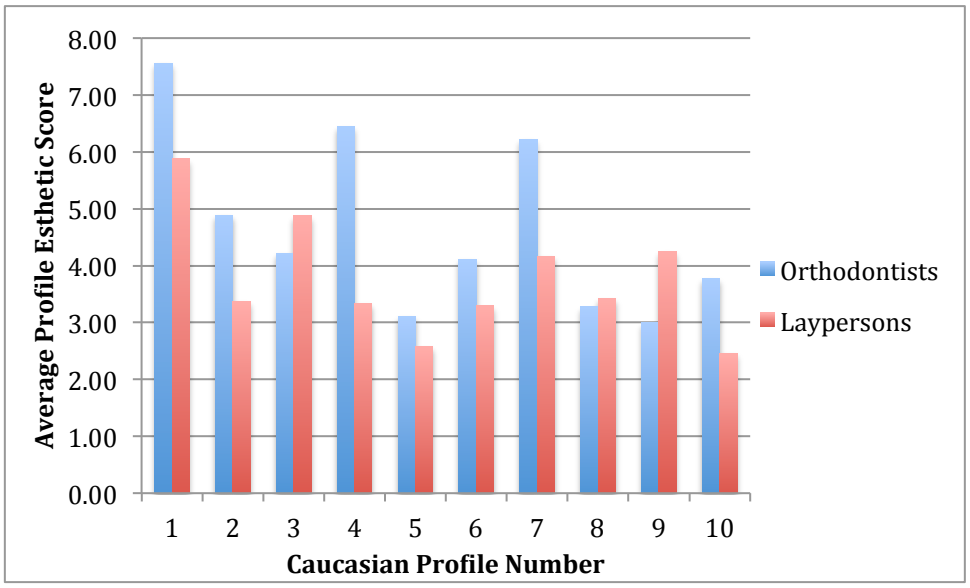


Figure 3.2. Average profile esthetic score for each Caucasian profile surveyed

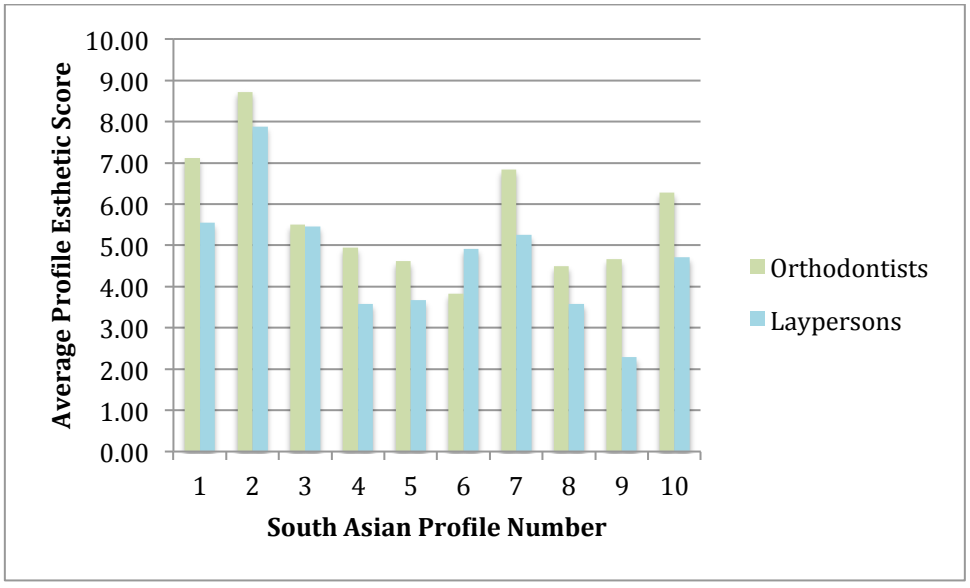


Figure 3.3. Average profile esthetic score for each South Asian profile surveyed

Profile type	Mean Score (SD) among Lay Raters	Mean Score (SD) among Orthodontists	P-value
All raters	4.23 (1.36)	5.18 (1.59)	0.001
Asians	4.69 (1.05)	5.70 (1.58)	0.009
Caucasians	3.76 (1.53)	4.66 (1.51)	0.060

Table 2. Mean scores for Caucasians and Asians as rated by layperson raters and orthodontist raters. Corresponding Standard Deviation (SD) and P value obtained from a paired t-test.

Profile type	Mean Score (SD) among South Asians	Mean Score (SD) among Caucasians	P-value
All raters	5.12 (1.57)	4.15 (1.38)	0.111
Lay	4.69 (1.53)	3.76 (1.05)	0.134
Orthodontist	5.7 (1.51)	4.66 (1.58)	0.150

Table 3. Mean scores for determined by layperson raters and orthodontist raters for both South Asian and Caucasian profiles. Corresponding Standard Deviation (SD) and P value obtained from a paired t-test.

	IMPA	U1-NA (degrees)	Interincisal (degrees)	Upper Lip to E-line (mm)	Lower Lip to E-line	Nasolabial Angle	Upper Lip Protrusion (mm)	Lower Lip Protrusion (mm)	Mentolabial Sulcus (mm)	Y axis (degrees)	ANB (degrees)	Wits (mm)
Profile 1 (SAF)	92.1	14.7	135.3	-1	4.5	113.2	4.1	7.3	-4.6	69.4	5.4	3.9
Profile 2 (SAF)	92.5	20.9	128.2	-11.4	-4.2	103.9	9.7	9.4	-10.2	61.6	2.3	-1.8
Profile 3 (SAM)	114.5	29.6	108.5	-4.2	0.3	100.3	5.2	5.6	-6.1	67.5	5.4	3.6
Profile 4 (SAM)	100.7	22.3	132.9	-2.6	-2.7	99.2	5.6	1.9	-7.1	58.2	3.8	4
Profile 5 (SAF)	87	0.5	151.9	-7.7	-2.3	117.3	0.3	2	-6.3	128.6	5.3	1.1
Profile 6 (SAF)	82.1	-6.5	170.7	-8.3	-4.8	107.5	3.5	2.4	-8.1	56.5	6.1	3.2
Profile 7 (SAM)	76.5	28.3	133.2	-10.5	-2.9	99.8	4.3	4.9	-9.6	72	-1	-9.2
Profile 8 (SAF)	94.4	16.1	124.6	-1.2	5.3	88.2	7.4	10	-7.4	71.1	7	1.7
Profile 9 (SAM)	87.5	15.2	136.8	-8.6	-1.9	103.7	5.4	6.9	-9.8	63.5	4.9	2.3
Profile 10 (SAF)	96.1	28.5	129.4	-8.7	-2.4	96.4	4.6	5.2	-9.7	66.4	-1.1	-2.3
Profile 11 (CF)	90.1	18.8	135	-6.8	-2	104.8	2.4	3.1	-6.5	129	2.2	-2.1
Profile 12 (CM)	87.4	4	160.2	-7.3	-5.9	129.4	-1.2	-0.9	-4.9	64.9	-1.5	-2.8
Profile 13 (CF)	89.2	17.3	128.6	-4.4	2.9	126.3	1.6	6.7	-1.9	119.6	5.4	2.1
Profile 14 (CM)	90.3	27.3	121.1	-5.5	-1.2	99.7	3.4	4.3	-4.5	65.1	2.6	-5.3
Profile 15 (CM)	91.9	28.4	124.6	-4.5	-1.8	118.2	3.3	3.6	-7.5	73.7	5.3	9.1
Profile 16 (CF)	94.6	16	140.9	-8	-6.4	106.6	1	-0.4	-2.1	123	2.7	-1.1
Profile 17 (CF)	89.6	20.3	129.2	-4.8	-2.1	124.1	1.6	1.7	-3.4	71.4	1.2	-5.1
Profile 18 (CM)	109.9	25.9	122.4	0.5	2.8	94.8	7.5	7	-9.1	63.8	6.3	6.2
Profile 19 (CF)	91.6	5.9	142.6	-0.1	4.1	119.2	5.2	7	-7.8	120.2	8.8	8.5
Profile 20 (CM)	87.9	31.2	134.7	-14.7	-7.6	89.7	0.8	2.9	-3.2	136.3	-4	-8

Table 4. Cephalometric Values associated with each profile

Hard Tissue Cephalometric Measurements

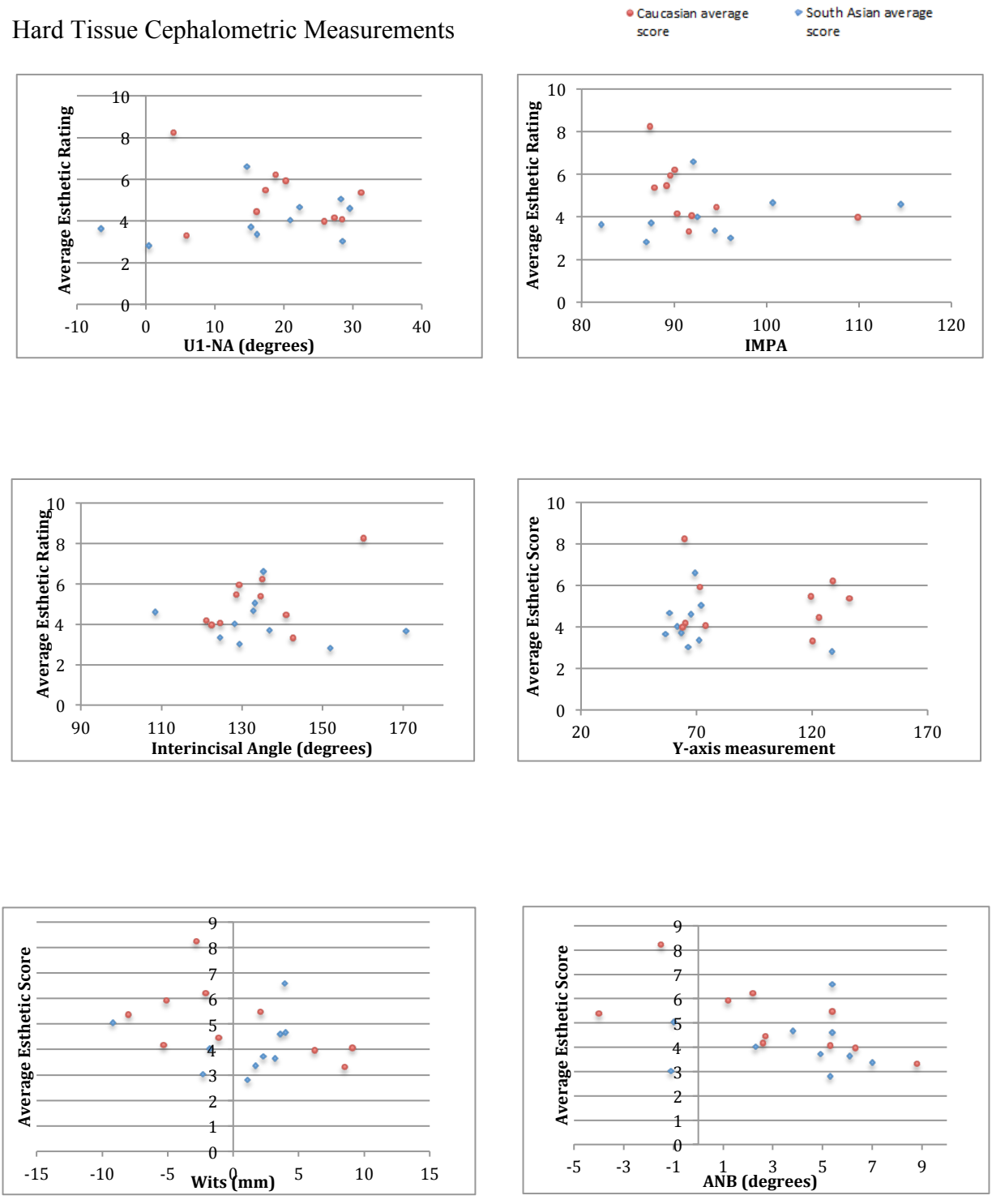


Figure 3.4. Hard tissue cephalometric measurements corresponding to average esthetic scores of each profile surveyed: U1-NA, IMPA, Interincisal Angle, Y-axis, Wits, ANB.

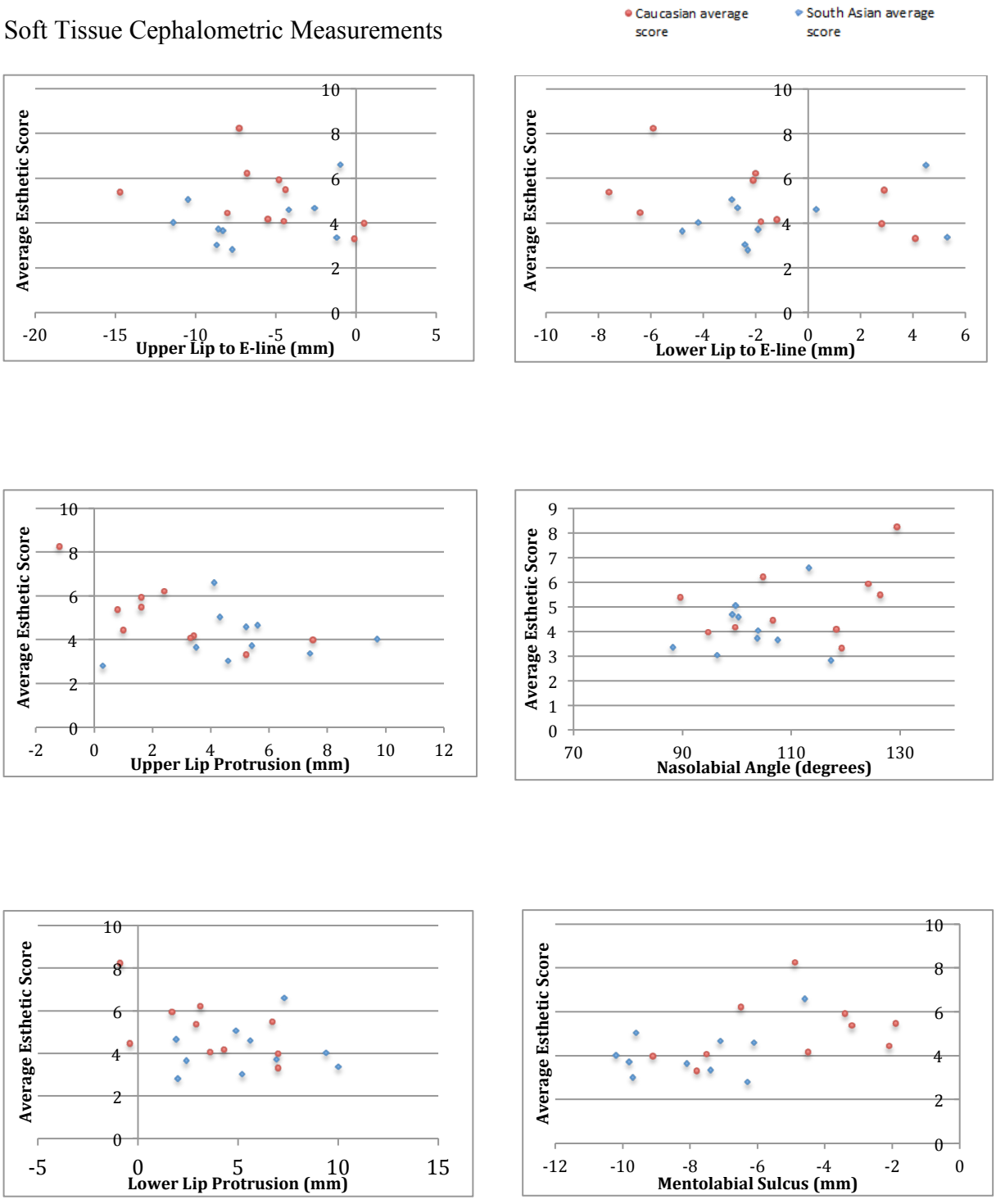


Figure 3.5. Soft tissue cephalometric measurements corresponding to average esthetic scores of each profile surveyed: Upper Lip to E-line, Lower Lip to E-line, Upper Lip Protrusion, Nasolabial Angle, Lower Lip Protrusion, Mentolabial Sulcus.

Cephalo-metric Measure	Both groups		Caucasians		South Asians		P-value comparing correlations in Caucasians to Asians
	Correlation	P value	Correlation	P value	Correlation	P value	
IMPA	-0.1492	0.5301	-0.4725	0.1679	0.0749	0.8370	0.16
U1-NA	0.0150	0.9498	0.3619	0.3041	0.2875	0.4205	0.18
Interincisal Angle	0.1292	0.5872	0.6025	0.0652	0.2382	0.5075	**0.045**
Y-axis	0.0234	0.9221	-0.0844	0.8168	0.3401	0.3362	0.58
ANB	-0.4478	**0.0477**	-0.6792	**0.0308**	0.0059	0.9872	0.15
Wits	-0.3295	0.1559	-0.5430	0.1048	0.0559	0.8781	0.25
Upper lip to Eline	-0.0496	0.8355	-0.4415	0.2014	0.3914	0.2633	0.088
Lower lip to Eline	-0.1788	0.4508	-0.4993	0.1417	0.3572	0.3109	0.077
Nasolabial angle	0.4128	0.0704	0.3893	0.2662	0.1919	0.5953	0.82
Upper lip protrusion	-0.4883	**0.0289**	-0.7658	**0.0098**	0.0970	0.7899	0.077
Lower lip protrusion	-0.3789	0.0994	-0.6239	0.0539	0.1353	0.7094	**0.031**
Mentolabial sulcus	0.5004	**0.0246**	0.3510	0.3200	0.4386	0.2048	0.84

Table 5. Correlation coefficients for cephalometric values and average esthetic scores for subgroups of Caucasians, South Asians, and both groups. Values in bold indicate statistical significance.

Chapter 4: DISCUSSION

I. Study Findings:

Orthodontists are faced with several variables when planning treatment for a patient. Esthetic considerations play a large role in determining best treatment options. Studies have shown that esthetic standards vary for different ethnic groups. Many authors have suggested that separate norms for distinctive populations are necessary. Specifically it has been documented that in South Asian populations, individuals tend to have a greater angle of convexity with a smaller mandibular plane angle than Caucasians. Often the midface is more retrusive in South Asian populations than in Caucasian populations as well (Kalha 2006). Such changes are noted in untreated adult individuals of this ethnic group and have been documented through previous studies of this group.

This study aims to determine if these standards translate to esthetic preference differences between ethnically different subgroups through a survey and cephalometric analysis of individual profiles. Both orthodontists and laypersons evaluated profiles of individuals of Caucasian and South Asian descent, and statistically significant differences were observed. The present study aimed to determine if esthetic expectations vary for these Caucasian and South Asian profiles, and if these different expectations are present between groups of laypersons and orthodontists. The first part of this study analyzed profile esthetic scores between survey respondents identifying themselves as orthodontists or laypersons. The findings show that overall, laypersons rated all profiles at a statistically significant lower average than orthodontists did. We conclude that for this sample the layperson group viewed all profiles as less attractive than the orthodontist group.

When esthetic ratings were compared among all raters for each subgroup, it was found there was no statistically significant difference between ratings for South Asians and Caucasians, implying that neither ethnic group was found to have an overall higher esthetic rating. This finding is expected since profiles selected represented a wide range of features, both skeletal and dental.

Cephalometric measurements were selected to provide quantifiable assessments of each profile. Analysis of these soft and hard tissue landmarks on the profiles shown to the raters provided insight regarding the variables that affect perception of esthetics among Caucasian and South Asian subjects. Among the Caucasian subgroup it was found that both ANB and Upper Lip Protrusion exhibited a statistically significant inverse correlation to esthetic scores.

The ANB value reflects jaw positions as they relate to the overall facial profile. As this angle increases, there is a larger discrepancy between the upper and lower jaws, resulting in a more convex profile. As this angle decreases, there is a smaller discrepancy between the upper and lower jaws, resulting in a straighter, more harmonious profile. Raters found this to be more esthetic among Caucasian profiles, as expected. However, there was no statistically significant relationship between ANB and esthetic score among South Asian profiles. This indicates that for South Asian profiles, a straighter profile did not result in a higher esthetic score as it did with the Caucasian subgroup among our survey respondents. This finding is consistent with previous studies that identify South Asian faces as exhibiting more convexity than those of Caucasians.

Upper Lip Protrusion also showed a statistically significant inverse relationship with profile esthetic score among Caucasian profiles. As the protrusion of the upper lip increases the

association with attractiveness decreases linearly. The upper lip position of each profile relative to Steiner's E-Line proved to be the most influential in determining the level of attractiveness among Caucasians (p value 0.0098).

Among Caucasians, there appears to be a noticeable inverse trend for these two cephalometric variables. Among South Asians, however, no trend was established for the same cephalometric variables. However, p-values for these differences were not found to be statistically significant.

Interestingly, when we compare Caucasians to South Asians, we find that there is a statistically significant difference between these groups for two different cephalometric values. Correlation coefficients for both Interincisal Angle and Lower Lip Protrusion were found to show statistically significant differences. Interincisal angle represents the angle between the long axes of the upper and lower incisors, and therefore exhibits lower values in more protrusive dentitions. A positive correlation (0.6025) was found for Caucasian profiles with interincisal angle, and almost no correlation was found for South Asian profiles and interincisal angle (0.2382). The difference in these correlation coefficients was found to be statistically significant (0.045). This implies that there is a statistically significant difference in correlation trends for this cephalometric variable between these two groups of profiles. It can be concluded that interincisal angle demonstrates a linear relationship to profile esthetic scores for Caucasian profiles, but does not show a trend for South Asian profile esthetic scores.

Similarly, it was found that coefficient correlations for lower lip protrusion values differed significantly (p-value = 0.031) between Caucasian and South Asian profiles. Among Caucasian

profiles, a relatively linear negative correlation was observed, indicating that as lower lip protrusion decreased, profile esthetic scores increased. This finding is consistent with previous studies by Steiner et al that demonstrated ideal lower lip position to be two millimeters behind the reference E-line. These studies by Steiner were performed using a Caucasian sample size. In our study, among South Asians, there appears to be no correlation between lower lip protrusion and esthetic score. The implication is that among this group of South Asians, lower lip protrusion does not impact esthetics as much as it does among Caucasians.

In general, it appears that for Caucasians in the study sample, there are some trends that correlate to profile esthetic scores. However, these trends are not evident for South Asian profiles. We conclude that there is more uncertainty regarding which features contribute to attractiveness among South Asian profiles when compared to Caucasian profiles. When evaluating if orthodontists should consider different esthetic goals while treating South Asian patients, it appears that there are certain features that are more esthetically acceptable among South Asian populations than among Caucasian populations. When considering treatment goals, it may be possible to maintain slightly greater than average lower lip protrusion or slightly greater than average dental protrusion without negatively impacting profile esthetics among this ethnic group.

II. Study Limitations and Future Studies:

The strength of the evidence in this study is dependent on both the sample size and the size of the observed differences. One of the study limitations is the small sample size of both profiles surveyed and survey respondents. Therefore, relatively large observed differences were required

in order to rule out the null hypothesis. Therefore, if smaller differences were present, the study would not be able to discern them, and so the study design carried insufficient power to detect smaller changes.

Another limitation in this study is a lack of diversity of the survey respondents. Perhaps obtaining responses from individuals of differing ethnic backgrounds and over a wider age range would provide a more comprehensive data set. Additionally, no data was obtained in this study regarding inter-rater reliability through a re-surveying of respondents. Future studies should include measures to improve upon these shortcomings.

Appendix 1. Survey

Survey of Profile Esthetics

Please fill out your demographic info at the top of this page first:

Please indicate: __ M __F **Age:** _____

Ethnicity (circle one):

Caucasian Native American African American Pacific Islander Latino South Asian East Asian

Are you an orthodontist (circle one): yes no If yes, how many years have you been in practice? ___

Please circle a number on the scale below to indicate the level of facial attractiveness you perceive in the following silhouettes. Profiles will be labeled with the ethnicity of the individual. 0 being least attractive and 10 being most attractive.

1) South Asian female

0 1 2 3 4 5 6 7 8 9 10

2) South Asian female

0 1 2 3 4 5 6 7 8 9 10

3) South Asian male

0 1 2 3 4 5 6 7 8 9 10

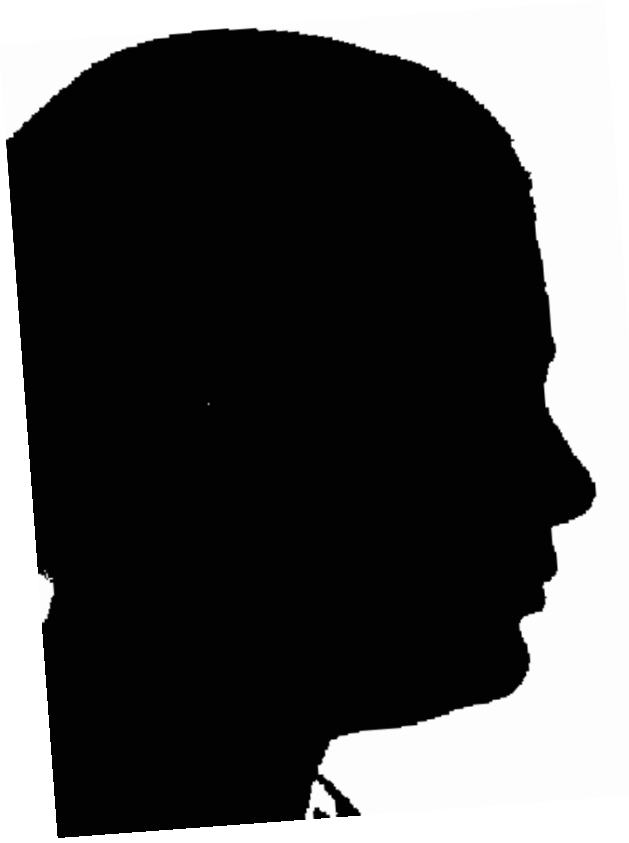
4) South Asian male

0 1 2 3 4 5 6 7 8 9 10

5) South Asian female

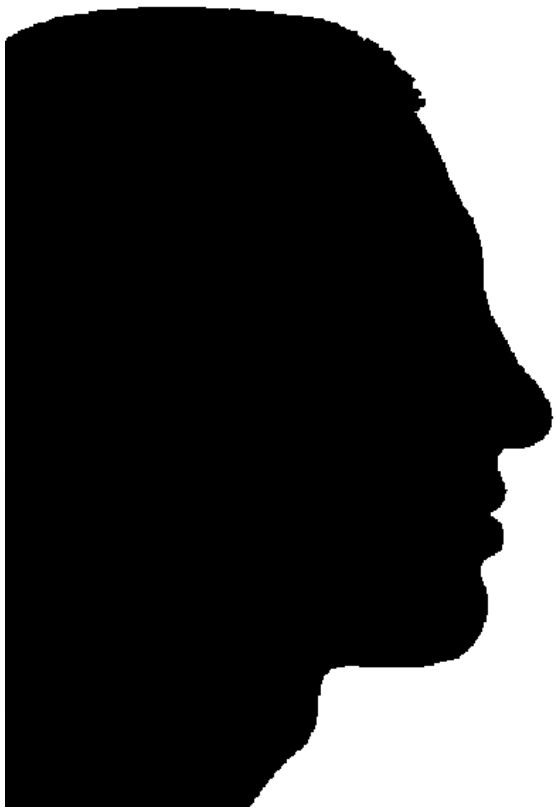
0 1 2 3 4 5 6 7 8 9 10

6) South Asian female



0 1 2 3 4 5 6 7 8 9 10

7) South Asian male



0 1 2 3 4 5 6 7 8 9 10

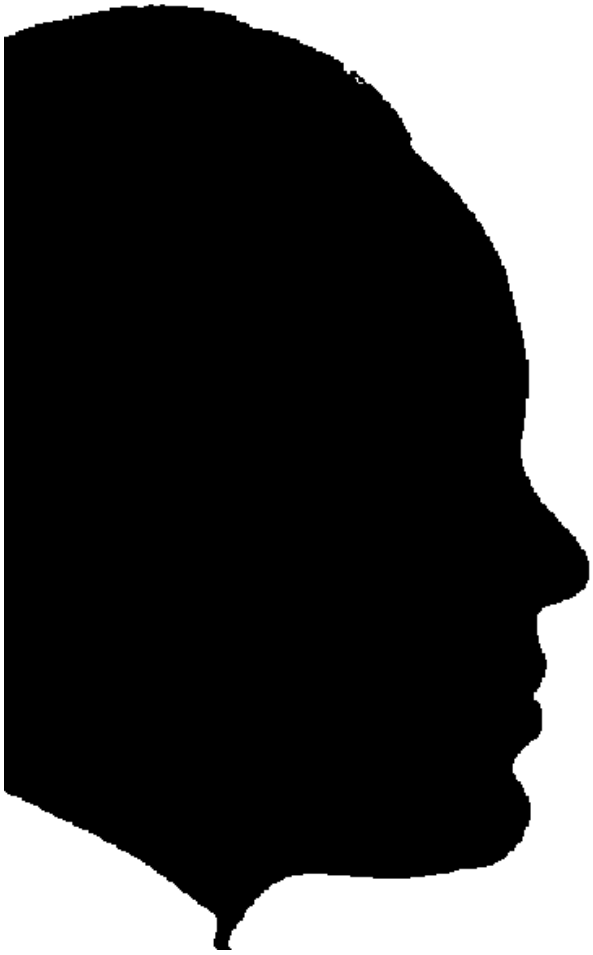
8) South Asian female

0 1 2 3 4 5 6 7 8 9 10

9) South Asian male

0 1 2 3 4 5 6 7 8 9 10

10) South Asian female



0 1 2 3 4 5 6 7 8 9 10

11) Caucasian female

0 1 2 3 4 5 6 7 8 9 10

12) Caucasian male

0 1 2 3 4 5 6 7 8 9 10

13) Caucasian female

0 1 2 3 4 5 6 7 8 9 10

14) Caucasian Male

0 1 2 3 4 5 6 7 8 9 10

15) Caucasian Male

0 1 2 3 4 5 6 7 8 9 10

16) Caucasian Female

0 1 2 3 4 5 6 7 8 9 10

17) Caucasian Female

0 1 2 3 4 5 6 7 8 9 10

18) Caucasian Male

0 1 2 3 4 5 6 7 8 9 10

19) Caucasian Female

0 1 2 3 4 5 6 7 8 9 10

20) Caucasian Male

0 1 2 3 4 5 6 7 8 9 10

2) If the following individual had orthodontic treatment resulting in a change from A to B, how would you rate this change? -5 = much worse. 0=no improvement. 5= much better.

-5 -4 -3 -2 -1 0 1 2 3 4 5

A

B

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