THREE-DIMENSIONAL PHOTOGRAPHY OF FACIAL MORPHOLOGY OF ADULT AFRICAN-AMERICANS COMPARED TO VARIOUS POPULATION SETS

by

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A THESIS

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DEPARTMENT OF ORTHODONTICS

ABSTRACT

The purpose of this study is to compare the facial morphologies of an adult African-American population to an adult Caucasian-American population using three-dimensional surface imaging. **Materials and Methods:** Three-dimensional facial images were captured via a stereo-photogrammetric camera system (3dMDface™ system). One hundred images of each population (African-American and Caucasian-American) were taken. Subjects were between 19-30 years of age, normal BMI, and no gross craniofacial anomalies. All facial images were aligned and combined using Rapidform 2006 Plus Pack 2 software to produce a male and female facial average for each population. The facial averages were then superimposed for comparison and the differences quantified and described. **Results:** Distinct differences were noted between the two populations. These differences were mostly in the forehead, alar base, and perioricular regions. The average facial difference between the African-American and Caucasian-American females was 1.18 ± 0.98 mm. The African-American females had a broader face, wider alar base, and more protrusive lips. The Caucasian-American females had a more prominent chin, malar region, and lower forehead. The average facial difference between the African-American and Caucasian-American males was 1.11 ± 1.04 mm. The African-American males had a more prominent upper forehead and periorcular region, wider alar base, and more protrusive lips. However, there was no notable difference in chin points between the two male populations. **Conclusions:** Average faces can be created from
three-dimensional photographs and used to compare the facial morphological differences between various populations and genders. African-American males tend to have a more prominent upper forehead and periocular region, wider alar base, and more protrusive lips. Caucasian-American males show a more prominent nasal tip and malar area. African-American females tend to have generally broader face, wider alar base, and more protrusive lips. Caucasian-American females show a more prominent chin point, malar region, and lower forehead.

Keywords: Facial morphology, African-American, Caucasian-American, 3D, Orthodontics
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I would like to thank my husband, John, for being by my side and helping me through these last several years. For providing for us and helping me raise our beautiful daughter, thank you.
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Orthodontics has historically been based on occlusion with facial esthetics falling into place once the teeth were in the correct position. In recent decades, more importance is being placed on soft-tissue treatment outcomes versus hard-tissue outcomes. Although occlusion is still a primary goal of orthodontics, the esthetic outcome, which encompasses the facial proportions and the teeth, is critical to the patient’s view of success. In the past, facial esthetics was evaluated in two-dimensions using radiographs and photographs. Today, facial esthetics can be more accurately visualized using three-dimensional (3D) techniques.

Types of Three-Dimensional Facial Imaging Systems

*Traditional Stereo-Photogrammetry*

Stereo-photogrammetry is a technique by which two or more cameras take photos from different angles and stitch the images together into a 3D image. The images are captured quickly, and the validity and reliability have been previously tested.
Laser Scanning

Laser scanning is often used in industries and is the gold standard to detect defects in structures.\(^2\) This technique can also accurately produce 3D images of individuals.\(^5\) The light source is deflected onto a patient’s face, and a detector captures the distorted light. By triangulating the distance between the source, the patient, and the detector, a 3D image of the patient’s face is created.\(^2\)

Structured Light Technique

The structured light technique is also used to produce a 3D image. To capture the image “structured light” is projected onto the surface of the individual. Cameras capture the distorted light as it reflects from the surface, and by triangulation, a 3D image is formed.\(^2\) Examples of structured light techniques include Moiré fringe patterns\(^6\), OGIS Range Finder RFX-IV\(^7\), CAM\(^3D\) system\(^8\), and C3D system\(^9\).

3dMDface™ System

This commercially available system is a combination of stereo-photogrammetry and the structured light technique. Three cameras (one color and two infra-red) on each side of the patient capture the image. While a light pattern is projected onto the patient’s face, the cameras calibrated at various angles on each side of the patient acquire the image. Image aperture is 1.5 milliseconds, and the clinical accuracy is 1.5% of the total variance.\(^10\)
Reliability of Three-Dimensional Imaging Systems

In the past, profile and soft tissue images were assessed based on two-dimensional (2D) photographs and cephalometric radiographs, but the practitioner could not evaluate the patient’s face in all three planes of space. Using 3D imaging, the pre-treatment image and changes that take place during treatment can be evaluated. While beneficial, it must also be reliable. Incrapera, et al.\textsuperscript{11} compared the pre-treatment and post-treatment cephalograms with pre-treatment and post-treatment 3D images to determine 3D reliability. Soft tissue nasion, the tip of the nose, the upper lip, the lower lip, and soft tissue pogonion were all analyzed. Results showed the mean difference between the 2D and 3D images was 0.312 mm, which was not significant. Additionally, the 3D images contained more information for assessment. Therefore, the use of 3D images for soft tissue analysis is as reliable as information obtained from cephalograms.

Kau, et al.\textsuperscript{5,12,13} found that 3D scans are reliable and reproducible, even when imaging children. When comparing scans taken three minutes apart and three days apart, his team found the reproduction of the image was accurate to within 0.85 mm; and when comparing male and female images captured one week apart, results showed the reproduction to be accurate within 0.7 mm for females and within 0.8 mm for males. Scans of children were also reliable, with the adult comparison group only being 0.5 mm better. These differences were not significant, and it was concluded that 3D images are an accurate representation of the individual.

\textsuperscript{3}
Uses of Three-Dimensional Imaging

Growth Changes

Analyzing growth changes is an important aspect of orthodontics. Growth is considered for initiating treatment, treatment planning, and treatment outcomes. Three-dimensional imaging allows for a more detailed and accurate study of growth changes than standard 2D photographs or cephalograms. Kau, et al. studied growth changes in 59 children, ages 12-14, over a 2 year period and found that boys have a greater and later change during growth than girls. Results also showed that the brows, nose, and chin become more pronounced, while the eyes and cheeks deepen over time. In another study, Kau, et al. used 3D scans to evaluate growth changes in identical twins and found that the magnitude and direction of growth can be better evaluated with this technology. This can be very useful when determining treatment plans and how different methods of treatment may affect the soft tissue.

Treatment Planning and Craniofacial Anomalies

As mentioned above, 3D imaging can help determine treatment planning based on growth. It can also allow comparisons of skeletal Class I to skeletal Class II and III individuals to evaluate differences of facial morphology. This allows multiple dimensions to be considered when treatment planning in both surgical and non-surgical cases.

Three-dimensional imaging is also used to assess the presence and extent of craniofacial anomalies. Using 3D scans, Tolleson, et al. were able to determine that facial asymmetries existed in a large percentage of patients with developmental dysplasia of the hip, which may require orthodontic treatment during the peak growth spurt or sur-
gical treatment in the future. Kau, et al.\textsuperscript{18} used 3D imaging to identify the areas of cranio-facial deformity in a boy with Binder syndrome. This was done by comparing scans of the patient to an average face created from scans of nonsyndromic boys of the same age. The information was then used in planning the surgical correction of the deformity.

\textit{Identifying Population Variations}

In addition to assessing anomalies, 3D imaging can also be used to detect facial differences in gender among certain age groups. Toma, et al.\textsuperscript{19} compared images of 380 children, aged 15.5 years, and found females to have more prominent eyes and cheeks, while males had more prominent noses and mouths. Kau, et al.\textsuperscript{20} compared facial shells of children, aged 11 years, and found the zygomatic area and lower jaw line to be more prominent in males. In a similar study, Kau, et al.\textsuperscript{21} found the major difference in facial shells of 80 adults to be the nasal area, zygomatic area, and lower jaw line. Males had a more prominent brow, broader and longer nose, thicker lips, and a more protrusive chin and mandible. These results show facial differences between genders, and these differences should be taken into consideration during orthodontic treatment.

There have also been studies to determine the facial differences among various populations. Bozic, et al.\textsuperscript{22} studied facial differences between Slovenian and Welsh males and females. Their results showed Slovenian men and women have a more protrusive mandible, giving them a higher tendency to be skeletal Class III. Gor, et al.\textsuperscript{23} compared men and women from Houston, Texas to men and women from Budapest, Hungary and found many differences. Hungarian women had larger noses, more prominent jaw lines, and less prominent cheeks and eyes compared to Houstonian women. Hungarian men had
less protrusive mandibles, larger noses, larger lips, and more prominent cheeks compared to Houstonian men. And when comparing the same Houstonian population to an Egyptian population, Seager, et al.\textsuperscript{24} found Egyptian women had more prominent cheeks, eyes, and lips. They also had smaller noses, more sloping foreheads, and smaller chins. The Egyptian men had more prominent lips, cheeks, eyes, and noses but a smaller chin and more sloping forehead. Kau, et al.\textsuperscript{25} studied the differences in all five of the above populations and concluded that major differences between European faces and Egyptian faces were the forehead, cheeks, and chin. They also found that North Americans and Europeans showed greater similarities. All of these studies show that there are significant facial differences among different populations, which should be taken into account when treatment planning for orthodontics. Norms can be developed from these studies for certain populations and used to determine treatment goals.

The African-American Population

Several populations have been studied using the new 3D imaging technique, but there are still many groups seen frequently in orthodontic offices that have not been studied, including African-Americans. According to the 2012 United States (US) Census, 12% of the 308.7 million people in the US are African-American. The total population of Alabama is 4.78 million with 1.25 million being African-American. African-Americans are one of the larger groups of minorities both in the US and Alabama.

Although African-Americans are commonly treated by orthodontists, there is not an existing 3D database of African-American norms. While there are studies on African-American cephalometric and profile norms, many orthodontists still treat to ideal num-
bers for Caucasians. As orthodontic treatment planning places a higher emphasis on soft
tissues, a database of these norms is greatly needed.

*Cephalometric Norms*

In a cephalometric study of 80 African-American children, Anderson, et al.\textsuperscript{26} found a wide range of acceptable apical base and incisor positions. The range of ANB was -0.5° to 9.5°, and the range of Wits was ±6.5 mm. Upper incisor to NA ranged from 12° and 3 mm to 39° and 14 mm. Lower incisor to NB ranged from 17° and 3 mm to 47.5° and 17.5 mm. Bailey, et al.\textsuperscript{27} compared cephalometric values for 71 African-Americans to Caucasians and found African-Americans to have larger SNA and ANB angles and more procumbent and proclined upper and lower incisors. Huang, et al.\textsuperscript{28} found African-Americans to be more hyperdivergent, with the palatal plane tipping up
and the functional occlusal plane tipping down.

*Soft Tissue Profile Norms*

In the past, the soft tissue profile has been evaluated in two-dimensions using
cephalograms and photographs. In a study by Sushner,\textsuperscript{29} the soft tissue profile of African-
Americans was evaluated by assessing 1,000 photographs. His results showed that Afri-
can-Americans had a more protrusive profile than Caucasian norms; and therefore,
should not be evaluated by the latter standards.

It is also important to consider that ethnicities have differing opinions of their
own ideal profiles. Nomura, et al.\textsuperscript{30} evaluated soft-tissue profile preferences for Europe-
an-American, Hispanic-American, Japanese, and African judges. Their results showed
that more retrusive profiles are preferred by the European-American and Japanese judges and that a wide range of profiles can be acceptable for African-Americans. Several other studies have found that both orthodontists and laypersons prefer greater profile convexity for African-Americans compared to Caucasians.\(^{31-33}\) There has also been a trend over the past few years for African-American models to have fuller lips with a more protrusive profile.\(^{34}\) All of these studies support the need for hard and soft tissue norms of various populations.

**Specific Aim of the Study**

The purpose of this study is to compare the facial morphologies of an adult African-American population to an adult Caucasian-American population using 3D surface imaging. Until recently, little has been published comparing facial morphologies of different populations based on 3D images. By using 3D imaging, facial morphologies from various populations and ethnicities can be combined into a database for use in future comparisons. Hopefully, this will provide a soft tissue reference to use as a guide when treating patients to their own ethnic or population norms.
CHAPTER 2
MATERIALS AND METHODS

Subjects were selected from two different American ethnicities: African-American and Caucasian-American. The Caucasian-American group was composed of individuals from Houston, Texas, and the African-American group was composed of individuals from Birmingham, Alabama. Each group included 50 males and 50 females. Approval was given by the appropriate institutional review board, and consent was obtained from each participant. Potential subjects were given a questionnaire and included in the study if they met the following criteria:

- Subjects of white and African descent
- Subjects between the ages of 19-30 years
- Subjects having no adverse skeletal deviations (mild Class II and III deviations were included)
- Subjects with no gross craniofacial anomalies
- Subjects with a normal body mass index (BMI) calculated from measured height and weight

Imaging System

The imaging system used for image capture was the 3dMDface™ system (3dMD LLC, Atlanta, Ga.). As mentioned previously, this system uses the structured light tech-
nique together with stereo-photogrammetry. Three cameras are positioned on each side of the subject, two infrared and one color. The system projects a light pattern onto the subject’s face, and the image is captured simultaneously by cameras placed at previously configured optimum angles. This creates the 3D view of the subject. The image captured is the full face from ear to ear and under the chin. The process takes 1.5 milliseconds at the highest resolution and is advantageous for taking images of young children. The stated manufacturer accuracy is less than 0.5 mm, and the reported clinical accuracy is 1.5% of the total observed variance. Previous studies have also shown that these 3D images are highly repeatable and that data can be acquired with high precision.

Image Acquisition

The system was calibrated using a portable device by 3dMD before taking the images. Subjects were seated on a stool with their face centered on the computer screen and asked to relax. The image was captured in 1.5 milliseconds and checked for acceptable quality. The capture was then transferred to the 3dMD software and converted to a 3D image.

Processing of Facial Shells

All acquired images were transferred to the Rapidform 2006 Plus Pack 2 (RF6 PP2) software (INUS Technology, Seoul, Korea) for analysis. Any details of the image that distracted from the face, such as the neck, hair, or shoulders, were cropped out of the image, and small surface defects or holes were automatically filled in by the software. The images were processed prior to comparison in order to preserve the shape, surface,
and volume using the RF6 PP2 software as described previously. The final product was one facial shell for each subject.

Average Face Constructions

The facial shells for each subgroup were aligned and combined to make an average facial shell using a best fit algorithm from previously validated subroutines of the RF6 PP2 software. The process by which the average shells were made has been previously reported and is summarized as follows:

1. Prealign the images by determining the principal axes of rotation, based on computing the tensor of inertia of each 3D image.
2. Manually position the image, when necessary, to improve the alignment.
3. Align on best fit using the built-in algorithm in the RF6 software.
4. Average the z-coordinates of the images based on normal images to a facial template.
5. Triangulate the point cloud to obtain an average face.
6. Improve the average face by filling in small holes and removing possible mesh defects.
7. Apply color texture.
8. Create shells with one positive and one negative standard deviation.

Parameters Measured

Four average facial shells were constructed from the individual images of each subgroup: African-American male (AA-M), African-American female (AA-F), Caucasian-
sian-American male (CA-M), and Caucasian-American female (CA-F). The morphologic differences of each subgroup were compared by superimposing the average shells using a specialized technique. This process required first manually aligning five points on the facial average: the inner canthus of each eye, the outer commissures of the lips, and the tip of the nose. The RF6 PP2 software then performed a fine registration using the best fit between the averages.

The parameters measured in this study were linear measurements of average shells, color histograms, and surface areas and shapes. These methods have been previously reported and are summarized below.

Linear Measurements

The linear measurements were calculated to determine the mean difference between the surfaces of the two shells. The measurement was made in millimeters and represents the sum total of all surface differences between the shells being superimposed for comparison. This measurement not only quantifies changes and differences between average shells but also indicates their similarities.

Color Histograms

Color histograms are maps that visualize the similarities and differences between two average shells. A base shell is selected as a reference for each color histogram. The result of superimposing a comparison shell on a base shell is a color spectrum, using red and blue as the two extremes. Red areas represent certain aspects of facial morphology on the comparison shell that are more prominent (positive changes) than that of the base
shell, and blue areas represent aspects of the facial morphology that are more deficient (negative changes). There are also black areas, which show similar facial morphology between the two shells.

**Surface Areas and Shapes**

The surface areas and shapes are automatically created by the RF6 PP2 software using a 0.425 mm tolerance level during shell comparison. This value was the result of a previous study, which showed that 90% of facial shells are within a 0.85 mm error. Therefore, the tolerance level of the average shell was set to 0.425 mm. Areas with variations less than 0.425 mm were considered similar, and areas with variations greater than 0.425 mm resulted in surfaces shapes and color deviations.
CHAPTER 3

RESULTS

Sample Size

The sample size included 200 individuals (50 CA-M, 50 CA-F, 50 AA-M and 50 AA-F) averaging 21 years of age for females and 22 years of age for males. Data collected from these samples was used to construct average facial shells for each subgroup: CA-M, CA-F, AA-M, AA-F (Fig. 1 and 2). Facial averages were then used to create comparisons between subgroups.

Figure 1. Average facial shells for Caucasian-American males (row 1) and females (row 2).
Figure 2. Average facial shells for African-American males (row 1) and females (row 2).

Measurements

The average shells of each subgroup were superimposed on each other by the previously described technique. For the purpose of comparison, a base shell was selected and is noted second in the diagrams. The results of the study are as follows:

Linear Measurements

Differences in the average absolute linear measurements between compared shells of the subgroups were noted. These absolute linear measurements ranged from 1.11 mm (AA-M vs. CA-M) to 1.65 mm (AA-M vs. CA-F) as shown in table 1. The gender specific differences for each group were 1.18 mm (AA-F vs. CA-F) and 1.11 mm (AA-M vs. CA-M).
Table 1

**Absolute linear measurements indicating differences between facial shells**

<table>
<thead>
<tr>
<th>Comparison Groups</th>
<th>Avg. Distance (mm)</th>
<th>Std. Dev. (mm)</th>
<th>Max. Distance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA-F vs. AA-M</td>
<td>1.13</td>
<td>0.90</td>
<td>4.23</td>
</tr>
<tr>
<td>AA-M vs. CA-M</td>
<td>1.11</td>
<td>1.04</td>
<td>4.64</td>
</tr>
<tr>
<td>AA-M vs. CA-F</td>
<td>1.65</td>
<td>1.15</td>
<td>4.64</td>
</tr>
<tr>
<td>AA-F vs. CA-M</td>
<td>1.21</td>
<td>0.99</td>
<td>4.25</td>
</tr>
<tr>
<td>AA-F vs. CA-F</td>
<td>1.18</td>
<td>0.98</td>
<td>4.25</td>
</tr>
<tr>
<td>CA-F vs. CA-M</td>
<td>1.33</td>
<td>1.20</td>
<td>4.47</td>
</tr>
</tbody>
</table>

*Color Histograms*

The results of the visual differences in the average facial shells are shown in table 2. The similarities between two subgroups ranged from 15.94% (AA-M vs. CA-F) to 27.47% (AA-M vs. CA-M). The gender specific similarities were 23.96% between AA-F and CA-F and 27.47% between AA-M and CA-M. The average linear measurements of the color histograms ranged from -0.01 mm (AA-F vs. CA-M) to 0.41 mm (CA-F vs. CA-M).

Table 2

**Signed color map measurements indicating differences between facial shells**

<table>
<thead>
<tr>
<th>Comparison Groups</th>
<th>Avg. Distance (mm)</th>
<th>Std. Dev. (mm)</th>
<th>% Similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA-F vs. AA-M</td>
<td>0.12</td>
<td>1.44</td>
<td>25.06</td>
</tr>
<tr>
<td>AA-M vs. CA-M</td>
<td>0.25</td>
<td>1.50</td>
<td>27.47</td>
</tr>
<tr>
<td>AA-M vs. CA-F</td>
<td>0.36</td>
<td>1.98</td>
<td>15.94</td>
</tr>
<tr>
<td>AA-F vs. CA-M</td>
<td>-0.01</td>
<td>1.56</td>
<td>21.81</td>
</tr>
<tr>
<td>AA-F vs. CA-F</td>
<td>0.19</td>
<td>1.52</td>
<td>23.96</td>
</tr>
<tr>
<td>CA-F vs. CA-M</td>
<td>0.41</td>
<td>1.74</td>
<td>24.38</td>
</tr>
</tbody>
</table>
Surface Areas and Shapes

The differences in surface areas and shapes between subgroups are shown in figures 3 and 4. The two subgroups that showed the largest comparison difference were the AA-M and the CA-F. The AA-M had a generally broader face, wider alar base, and more protrusive periorcular region. However, when compared to the CA-F, the nasal tip, malar region, and lower forehead were more retrusive. The AA-F compared to CA-M differed second most, with the AA-F having a more protrusive upper forehead, malar region, and lips.

There were also noted differences between gender specific subgroups. The AA-M compared to the CA-M varied mostly in the periorcular region, the alar base, and lips. While the AA-F compared to the CA-F varied mostly in width of the face, alar base, and lips.
Figure 3. Absolute color histograms showing the differences between average facial shells.
<table>
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<tr>
<th></th>
<th>AA-F vs AA-M</th>
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<th>AA-M vs CA-M</th>
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<th>AA-M vs CA-F</th>
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<th>AA-F vs CA-M</th>
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<th>CA-F vs CA-M</th>
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</thead>
</table>

Figure 4. Signed color histograms showing the differences between average facial shells.
**Females (AA-F vs. CA-F)**

In comparing AA-F to CA-F, the AA-F subgroup had a generally broader face, wider alar base, and more protrusive lips. CA-F showed a more prominent chin point, malar region, and lower forehead (Figure 5). The comparison results demonstrated a 23.96% similarity (Table 2).

![Signed color histograms comparing the average African-American female to the average Caucasian-American female.](image)

**Males (AA-M vs. CA-M)**

When comparing AA-M to CA-M, AA-M showed a more prominent upper forehead and periocular region, wider alar base, and more protrusive lips. Results also showed there was no significant difference between chin points (Figure 6). The male facial shells displayed a 27.47% similarity (Table 2), the most similar of all comparison groups.

![Signed color histograms comparing the average African-American male to the average Caucasian-American male.](image)
CHAPTER 4

DISCUSSION

The Use of Facial Averages for Comparison

Three-dimensional imaging has many uses: evaluation of growth changes, treatment planning, and comparing various populations. The purpose of this study was to use average facial templates obtained from 3D imaging to compare facial morphological differences between adult African-Americans and Caucasian-Americans. Several studies have shown that there are significant differences between males and females of differing ethnic backgrounds. The results of this study also showed significant differences between African-Americans and Caucasian-Americans in the width of the face, the width of the alar base, and the fullness of the periorcular area.

Bozic, et al. studied facial differences between Slovenian and Welsh males and females and found Slovenian men and women to have a more protrusive mandible. Gor, et al. compared men and women from Houston, Texas to men and women from Budapest, Hungary and found Hungarian women have larger noses, more prominent jaw lines, and less prominent cheeks and eyes. Hungarian men have less protrusive mandibles, larger noses, larger lips, and more prominent cheeks. Seager, et al. found Egyptian women to have more prominent cheeks, eyes, and lips compared to Houstonian women. The Egyptian men had more prominent lips, cheeks, eyes, and noses but a smaller chin and more sloping forehead. These studies, along with the results of this study, show that there
are facial differences among different populations that need to be taken into consideration during orthodontic treatment.

Differences Between Subgroups

To determine the differences between AA-M, AA-F, CA-M, and CA-F, the facial averages of each subgroup were compared. The results showed significant differences, as evidenced by the color histograms. When analyzing the linear measurements, color histograms, and surface areas and shapes, the areas that differed most were in the lower half of the face. This area is what is most influenced by orthodontic treatment, and therefore, important to consider when treatment planning.

The majority of previous studies on African-American soft tissue have been based on 2D images.29-34 These studies found that African-Americans tend to have a more protrusive profile with fuller lips. This study found similar results but allows visualization of the facial morphological differences in three-dimensions. This is important because individuals are usually viewed from many different perspectives, not just from a frontal or profile view.

Clinical Implications

When treatment planning an orthodontic case, treatment objectives are chosen on a case by case basis. There are certain overall diagnoses that patients are grouped into, but many details are individualized. Patients are always asked to identify their “chief complaint,” and it is the goal of the orthodontist to address it. Therefore, the information
used to help in the diagnosis should be based on averages for that individual’s gender and ethnicity.

This study shows specific differences between these two populations that are important to help establish a set of norms for the African-American population. More specifically AA-M tend to have a more prominent upper forehead and periocular region, wider alar base, and more protrusive lips compared to the CA-M. AA-F had a tendency toward a generally broader face, wider alar base, and more protrusive lips. Knowing what the norm is for this specific population allows the orthodontist to set proper treatment goals, preventing all patients from being fit into “one mold.”

These observations are based on facial shells taken from one sample and may be different from a sample taken elsewhere. There may be some sample bias because subjects were college students and not an average sample taken from the community. However, the results do show that there are differences between populations and subgroups within populations. It also shows the importance of growing the database of average facial morphology for various populations worldwide.

Forming this database for adult African-Americans gives an opportunity for future research to visualize the 3D face with the skeleton and hard tissue. This would also allow investigators to compare differences in facial morphology due to treatment decisions such as extractions. In addition, comparisons could be made regarding facial attractiveness of different populations in multiple dimensions. Having a database of norms for various populations provides a foundation for the start of many studies in the future.
CHAPTER 5
CONCLUSIONS

- Average faces can be created from 3D photographs and used to compare the facial morphological differences between various populations and genders.

- The comparison of AA-M and AA-F averages to CA-M and CA-F averages demonstrates specific facial morphological differences.

- AA-M tend to have a more prominent upper forehead and periocular region, wider alar base, and more protrusive lips. CA-M show a more prominent nasal tip and malar area.

- AA-F tend to have a generally broader face, wider alar base, and more protrusive lips. CA-F show a more prominent chin point, malar region, and lower forehead.
REFERENCES


APPENDIX A

IRB APPROVAL

UAB's Institutional Review Boards for Human Use (IRBs) have an approved Federalwide Assurance with the Office for Human Research Protections (OHRP). The Assurance number is FWA00005960 and it expires on September 29, 2013. The UAB IRBs are also in compliance with 21 CFR Parts 50 and 56.

Principal Investigator: KAU, CHUNG H
Co-Investigator(s): X110802009

The IRB reviewed and approved the above named project on 9.2.11. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services. This Project will be subject to Annual continuing review as provided in that Assurance.

This project received EXPEDITED review.
IRB Approval Date: 9.2.11
Date IRB Approval Issued: 9.2.11

Marilyn Doss, M.A.
Vice Chair of the Institutional Review Board for Human Use (IRB)

Investigators please note:

The IRB approved consent form used in the study must contain the IRB approval date and expiration date.

IRB approval is given for one year unless otherwise noted. For projects subject to annual review research activities may not continue past the one year anniversary of the IRB approval date.

Any modifications in the study methodology, protocol and/or consent form must be submitted for review and approval to the IRB prior to implementation.

Adverse Events and/or unanticipated risks to subjects or others at UAB or other participating institutions must be reported promptly to the IRB.
December 12, 2012

MEMORANDUM

TO: Leslie Talbert, DMD

FROM: Nancy Stansfield RN, MSN, CIP
       Assistant Director
       Institutional Review Board

    PI- Chung H. Kau

This memo is to verify that Leslie Talbert, DMD is listed as an investigator on the above referenced protocol which was approved by the IRB beginning September 2, 2011.