THREE-DIMENSIONAL AGE-RELATED CHANGES IN THE ADULT FACE: AFRICAN AMERICAN FEMALE POPULATION

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ABSTRACT

Objectives: Treatment of older adults is one of the fastest growing areas in orthodontic practice. The objectives of this study are to: 1. Investigate the aging of the female African American face using three-dimensional surface imaging to understand how the soft tissue of the face matures in relation to the teeth and 2.) Compare the effects of aging on African American female faces to aging of Caucasian female faces. **Methods**: This is a cross-sectional study of 100 African American females with balanced faces. Five age groups (in years) were included: [20-30], [31-40], [41-50], [51-60], [61-70]. Three-dimensional (3D) surface images of the face were taken using the 3dMD system (3dMDface, Atlanta, GA). Twenty-eight soft tissue landmarks were plotted and their coordinates recorded using the Vultus software (3dMDface, Atlanta, GA). Means and standard deviations of distances from Nasion (origin) to all landmarks were calculated for each group and compared across the five age groups using an ANOVA test. Pairwise comparisons utilizing Tukey's honest significance test (to account for multiple comparisons) were performed when the overall model ANOVA F-test was statistically significant. The mean distances between African-Americans and Caucasians were compared using Student's t-test. **Results:** Significant differences ($p<0.05$) by age groups were observed for the mean distances from Nasion to the soft tissue median points pronasale, subnasale, labiale superius, stomion, chin-throat point and the bilateral points exocanthion, orbitale, alare, subalare, christi philtri, cheilon and zygion. Pairwise comparisons revealed that the differences were among those aged 51-60 or 61-70 years for all significant associations. **Conclusions:** Soft tissue changes of the aging African American female face are most evident around the midface and the mouth after age 50. The midfacial landmarks and chin-throat distance are significantly more elongated in the African American group compared the Caucasian population. The norms established in this study might serve as quantitative references for treatment of adult orthodontic patients and comparison to other races and genders.

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LIST OF ABBREVIATIONS

2D..two-dimensional

3D..three-dimensional

BMI..body mass index

AA...African American

C..Caucasian

CHAPTER 1

INTRODUCTION

Adults Seeking Orthodontic Treatment

Traditionally, orthodontic treatment focused on adolescents and the ability to direct growth orthopedically and dentally to achieve a harmonious dentition. However, not every child receives the privilege of orthodontic care and recently, more adults have shown interest in orthodontic treatment. According to the American Association of Orthodontics, the official organization representing the orthodontic profession, one out of five new orthodontic patients are adults.[1] There are numerous reasons why an adult pursues orthodontic treatment. One such reason is that some adults never had access to orthodontics as a child and aim to change one or multiple aspects of their smile. As they gain financial independence, many of these individuals seek the treatment they did not receive at a younger age to improve their dentition. Also, many older adults request orthodontic treatment as part of a multidisciplinary treatment plan to restore a mutilated dentition after years of neglect. It is believed that treatment for older adults is now the fastest growing area in orthodontics.[2] Fortunately, achieving tooth movement proves possible at any age given that the teeth are not fused to the underlying alveolar bone. Dento-alveolar tooth movement occurs when pressure and tension are transferred from the tooth to the periodontal ligament, leading to the molecular cascade that begins the process of bone remodeling. Through this mechanism, orthodontists accomplish the task of aligning the teeth and correcting the occlusion. The main challenge that faces orthodontists when treatment planning for adult patients remains the overall aging process that takes place for the face and dentition. In terms of the teeth, older individuals often having missing teeth, previous restorations that may need replacement and yellowing of teeth that proves a cosmetic challenge. They also may suffer from bone loss due to periodontal disease, missing papillae, uneven gingival margins and a less than ideal oral health state to begin orthodontic treatment.[3] Therefore, there is always a need for a team approach to adult treatment, integrating many dental specialists to obtain optimal results.

Paradigm Shift

Besides aging of the dentition, the orthodontist also must address aging of the face and soft tissues. With changes that occur in the facial soft tissues and profile over time, treatment planning for optimal esthetics in adolescents may not translate to adult patients[4]. Therefore, there is a need for data on adult aging of the facial tissues.

Historically, craniofacial dimensions were used in anthropometry to determine normal proportions in a population of individuals. Distances and angles were measured directly on skulls with calipers, using defined cranial and facial landmarks[5] With the advent of radiography and the creation of the lateral cephalogram by Broadbent, orthodontists began to utilize hard and soft measurements made on a cephalogram to plan ideal treatment and ensure lower incisors stayed over basal bone. The orthodontic treatment plan centered on the lower incisor, as this was believed to provide optimal stability of treatment results. However, the orthodontic specialty has witnessed a recent paradigm shift that focused the clinician's attention on the soft tissue of the dace and lead to newer ways to approach treatment planning.[6] Today, orthodontists typically analyze craniofacial dimensions and soft tissue parameters with clinical examinations and using two-dimensional

(2D) photography to aid in diagnosis. However, a transition from 2D to three-dimensional (3D) imaging is currently underway.

Three-Dimensional Surface Imaging Technology

Previously, financial considerations and excessive exposure to harmful emissions made 3D imaging difficult. Using engineering technology, 3D scanners that originally captured inanimate objects were transformed to be able to capture live subjects in a very accurate manner. With the evolution of this technology, capturing craniofacial soft tissue surface images for diagnosis, treatment planning and research now proves possible. This technology enables clinicians and researchers to study the soft tissue of the face in a quicker, more reliable and less invasive method than taking direct clinical measurements, especially in children and those with disabilities.[7]

Three-dimensional facial imaging employs high-resolution optical cameras to capture a set of images that are then processed with the appropriate software, yielding a reconstruction of the face in three-dimensions. The acquired data set exists as a collection of points; each defined by an x, y and z coordinate system. Together they represent a mathematical expression of the human face using geometry. Multiple viewpoints allow for a more accurate picture, so a continuous coordinate system is used with multiple cameras each taking a picture from different angles. It is possible to also collect color and texture information that overlays the produced 3D geometric model to give the 3D image a more recognizable, human look.[8]

As with other technology, more than one method exists to capture 3D surface mages. The laser-based systems initially dominated the field, using geometric triangulation. The laser hits the object, scatters light and due to the known distance of the object to the laser, uses this light to calculate distances and creates a coordinate system. However, the human face takes up to 20 seconds to capture in this manner and it can be difficult for human subjects to remain completely still for this amount of time. Another advocated technique, the structured-light technique, projects a pattern of white light onto the subject and calibrates using the distortion of the white light pattern. To be as accurate as possible, multiple images are captured, which extends the time of acquisition, again being detrimental to gathering data on human subjects. To solve this issue, the stereo photogrammetry technique uses a stereo pair of photographs to identify and overlap surface features to turn a 2D image into a 3D image. The stereo approach can be passive or active, with the passive version resolve surface details, like freckles or skin pores. However, the active version combines the natural landmarks with an unstructured light pattern to provide more information for the geometric model, which makes this technique work better in varying lighting situations. [8]

With the development of the 3dMDface™ system (Atlanta, GA), two of these techniques, structured light and stereo-photogrammetry, were combined. Utilizing six medical-grade, machine-vision cameras with three on each side (one in color and two in infra-red), a random light pattern projects onto the subject and these cameras record a clean and precise image. The manufacturers claim a 1.5 ms capture time with an accuracy of <0.5 mm and a 1.5% clinical accuracy of the total observed variance, making this an ideal platform to capture human faces. Kau et al. advocate the use of the 3dMD system for many applications, including gathering facial averages, gender analysis, facial growth changes, craniofacial anomalies and orthognathic surgery planning.[9]

Reliability and Predictability of the 3dMD face system

Other authors have independently tested the precision and reliability of the 3dMD face system. Aldridge et al. aim to use the 3dMD face system to examine phenotypic similarities in certain syndromes to understand the transition from genotype to phenotype. The authors state that the reliability of the system must be assessed in terms of obtaining the images and being able to accurately plot facial landmarks. To achieve this, 15 subjects were recruited of normal and syndromic morphologies. Landmarks were plotted twice on non-consecutive days by the same investigator and statistical analysis showed that landmarks were able to be located with a high degree of precision. The study also denoted that the error due to digitization and the imaging system was a very small proportion of the total error and that error associated with landmark placement is in the sub-millimeters. This information indicates that the 3dMD system proves reliable and repeatable for taking anthropometric measurements on human subjects. However, the authors showed that glabella and right and left gonion had the most error of all the 20 plotted landmarks[7]

Another study by Plooij et al. looked at the reliability of plotting landmarks on 3dMD images. Two investigators, one oral-maxillofacial surgery resident and one orthodontic resident, plotted 49 landmarks on 20 previously gathered 3dMD facial images at two differing time points. Statistical analysis showed no statistically significant inter-observer differences between the two observers except for three of the 49 landmarks (left endocanthion, left nostril top and right nostril top). Observer 1 identified two landmarks with significant intra-observer differences, while observer 2 had three landmarks with significant differences between the two time periods when landmarks were plotted. The authors conclude that plotting anthropometric landmarks on 3dMD images is reliable and reproducible. However, they state that midline structures are easier to locate predictably than paired structures on the nose and ears.[10]

In addition to previously mentioned studies, Heike et al. designed a study test reliability of the 3dMD system for patients with and without craniofacial syndromes. The authors recruited 40 total patients, 20 morphologically normal and 20 with 22q11.2 deletion syndrome (also known as velocardiofacial syndrome). This syndrome includes altered facial morphology such as short palebral fissures, small mouth and ears and a tubular appearance of the nose. The investigators took direct anthropometric measurements with a caliper along with 3D facial images on the subjects. The study measured intra-observer and inter-observer differences and noted that the inter-observer measurements were higher, indicating differences between investigators, although they trained together. They deduce that studies using more than one investigator plotting landmarks need to account for this variable. Also, they examined the differences between taking clinical measurements with a caliper versus 3D imaging measurements. While neither is the gold standard, some clinicians may not have access to a 3D imaging system and may need to be to compare clinical measurements with previously found digital measurements. They found it was easier to plot landmarks associated with the lips directly on the patient, while measurements around the eyes proved easier on the 3D images. The authors offer several recommendations based on their experience with the 3dMD system, such as to palpate and mark bony landmarks before taking the image, removing the hair off the face a headband or barrettes to see facial and ear landmarks obscured by hair and to add an accessory light if shadows make landmarks under the nose indistinct.[11] Together, these studies highlight the reliability and precision of using 3dMD images in identifying and plotting craniofacial anthropometric landmarks in subjects with and without normal facial morphology.

Applications for 3D Surface Imaging of Human Faces

Using the three-dimensional surface imaging, many research groups have investigated the changes that occur in the human face during the normal events of growth and development of adolescents. Kau and Richmond (2008) took a sample of 59 growing children in Wales and used a laser scanning system to evaluate growth over a period of two years. The 33 males and 26 females were scanned five separate times over the study period, which each scan taking approximately seven seconds. A software package created facial shells of each individual from each time point and provided a method to compare growth within each individual and between subjects. The authors found that a downward and forward growth trend exists in the nasal and soft-tissue nasion area, as well as at the lips and an overall increase was seen in the vertical dimension. These changes expressed more so in males than females and at a later time period in males. The authors conclude that this 3D technology is useful for evaluating growth changes in adolescent faces over time.[12]

In 1999, Ferrario et al. investigated growth changes in adolescents as well by using a 3D mesh diagram analysis. The authors examined 2023 subjects, 1157 healthy children and adolescents and 191 young adults and recorded 22 facial landmarks on each individual. A standard mesh was created for each sex and age class and size normalization was performed. The authors compared meshes male to female and between age classes to deduce growth and development changes. When compared to young adults, children showed the most changes in the soft tissue profile. Prominent shape differences existed in the forehead, nose and chin areas. Males and females had similar growth patterns until the age of 11, when growth differences became evident. Overall, males presented with larger foreheads, longer noses and more inferior and prominent lips than the females in the equivalent age groups.[13] From these studies, it is evident that 3D facial scanning technology aids in the collection of information on growth and development of adolescents. In addition to this function, it also serves to describe the difference between genders and ethnicities.

The differences existing between males and females have been the fodder of numerous jokes and observations throughout the ages. Although these distinctions often prove self-evident in terms of facial morphology, 3D facial scanning aids in the quantification of how the structures vary between the genders. Kau et al. in 2006 developed facial templates for males and females using laser scans of a sample of 80 adults. After averaging the faces, they found that the areas of greatest discrepancy existed in the nasal, zygomatic area and lower jaw line. In males, the brow showed as more prominent, the nose was broader and longer vertically, the lips were thicker and males had a more protruded lower jaw and chin. Knowing and understanding the various deviations between the genders proves helpful when diagnosing and treatment planning patients with facial disproportion to attempt to achieve a facial outcome harmonious with the patients gender.[14] Other than observing facial differences between genders, this technology assists in determining aberrations existing between ethnic groups as well.

Convention asserts that differences can be noticed between ethnic groups. Some racial stereotypes even target the perceived universal characteristics of a certain ethnic group. Bozic et al. looked at facial morphology differences in two white, European populations; Slovenian males, Slovenian females, Welsh males, Welsh females. The null hypothesis stated that no differences would be noted between these two populations. However, after collecting facial scans of 187 adults and averaging the faces to produce templates of four groups (Slovenian males, Slovenian females, Welsh males, Welsh females), the authors concluded that the Slovenian population exhibits a tendency towards a class III facial pattern compared to the Welsh population. Males between the two ethnicities showed similarities of up to 70.2%, whereas females only showed a 43.7% similarity. Therefore, differences do occur between two European ethnicities and the null hypothesis was rejected.[15]

A similar study by Seager et al. compared Egyptian adults with white adults from Houston, Texas. One hundred eighty-eight subjects provided facial scans, which were superimposed to produce facial averages for each ethnicity and gender. The authors found that Egyptian female faces showed more prominence in the malar region, periocular region and lips and their foreheads were more sloped, with smaller bridges of the nose and a less pronounced chin. Egyptian males also had more prominence in the malar, periocular and lip regions, with a sloping forehead and less prominent nasal tip and chin than Houstonian males. Due to the overall tendency for protrusion of the Egyptian face, the authors conclude that extractions may be recommended more in orthodontic treatment plans for this population to reduce the amount of protrusion.[16] Therefore, the differences in facial morphology between ethnicities can impact orthodontic treatment planning when attempting to achieve an ideal facial pattern with orthodontic treatment decisions.

In light of the gender and ethnic disparities in facial morphology, one might assume that the age of the patient presents as another variable affecting ideal soft tissue treatment planning. Orthodontic treatment geared at growth modification and redirection does not apply to the adult population that currently frequents orthodontic offices. This population places new demands on orthodontists and understanding the aging process of the soft tissues of the face proves increasingly more important as these patients desire optimal esthetic treatment. Sforza et al. examined aging of the face by gathering a large sample of Italian subjects ranging in age over eight decades. The authors recruited 918 healthy subjects for 3D facial scans. Fifty landmarks were plotted for each face and measurements were computed for linear distances, ratios, areas and volumes and the data analyzed for differences between ages and gender.

The authors divided the face into three areas for discussion purposes: lips, orbital region and external nose. In terms of the lip area, males had larger labial volumes, total lip area, plus mouth and philtrum widths than females. However, women showed an increased vermillion height to mouth width ratio. All measurements showed gender and age related changes. Mouth width and lip volume increased with age until late adolescence, when it began to decrease. Vermillion height to width ratio also decreased with age.[17] These results help the orthodontist realize that lips tend to decrease in volume and sag with age. When observing the orbital region, the authors found that linear measurements are larger in males. All measurements had significant age and gender interactions with intercanthal widths, orbital height, length of eye fissure and soft tissue in the orbital area increasing with age, with more change seen in males than females. Overall, the perioccular area experienced an increase in volume and a downward shift of soft tissue as individual's age.[18] Along with the lips and eyes, the external nose also exhibits changes between genders and over time. In males, there is a larger nasal volume, as well as nasal area and all linear distances measure as larger. However, no gender differences were seen in angles or in nasal-tip protrusion to nasal-height ratio. All measurements were significantly affected by age, with an increase in nasal volume and area and a decrease in nasal tip angle. Overall, the nose becomes larger and wider with time and the nasal tip tends to droop.[19] For the orthodontist, these changes may affect the treatment plan if the patient expresses discontent with their profile or acuteness of the nasolabial angle. Extractions may be contraindicated in older adults due to a decrease in upper lip thickness, making the nose appear larger and more pronounced.

Along with the previously mentioned applications of 3D facial imaging, several research groups are now applying this technology to the study of the phenotypic differences seen in patients with craniofacial syndromes or abnormal morphology. Fang et al. are interested in using this technology to help identify patients with fetal alcohol syndrome (FAS). These individuals show growth deficiency, structural abnormalities of the central nervous system and neurobehavioral deficits. Morphologically, these individuals often exhibit short palpebral fissures, smooth philtrum, thin vermillion border of the upper lip and midface hypoplasia. Although there is currently no intervention to change the outcomes of FAS, special education efforts and management can be utilized in identified patients. The authors state that diagnosis can be difficult in adolescence and adulthood and the ideal time to diagnose is at age five. Subjects were recruited from Cape Town, South

Africa and Helinski, Finland. A total of 149 subjects were enrolled, which were categorized as Finnish Caucasian (FC) or Cape colored (CC) and for each group, a matched control group was created. The study utilized Minolta Vivid 910 laser scanner at both sites to obtain 3D facial images. The images were aligned, features analyzed and a mathematical equation designed to select features differing between the study groups that can automatically categorize FAS and control subjects. For the FC group, the automated technique could identify FAS 88.2% of the time and the control group 100% of the time and 15 identifying features were found. For the CC group, FAS identification correctly occurred for 90.9% of the faces and for 90% of the controls, with 19 identifying features discovered. The authors conclude that 3D imaging can add to clinical examination in diagnosing FAS and can be used in remote areas of the world to give underserved populations access to medical diagnosis through telemedicine.[20]

Other craniofacial anomalies are also amenable to examination and diagnosis with the use of 3D surface imaging, including non-syndromic cleft lip with or without cleft palate (CL/P). Weinberg et al. take this idea a step further by looking at 80 non-affected parents of children with CL/P and 80 matched non-related normal controls, aiming to determine if face shape may be a predisposing factor to CL/P in offspring. The Genex 3D camera (Genex Technologies, Inc., Kensington, MD) or the 3dMD system were used to collect the images and parents with a positive family history for CL/P did show a statistically significant difference in facial morphology and shape than those without a family history. The fathers had an inferior and anterior shifted mandible and a superior, posterior and medial shift of the nasolabial area. The mothers with a family history of CL/P had more subtle differences, including lateral displacement of the alare points leading to a widened base of the nose. Overall, facial shape changes associated with CL/P included a retruded midface, reduced upper facial height, increased lower facial height and increased width between the orbits. The authors conclude that using craniofacial phenotypic morphology should be recommended in future studies examining families with a history of CL/P.[21] Along with the use of 3D imaging for analysis of craniofacial syndromes and anomalies, current research is also examining the connection between facial dysmorphogenesis with brain dysmorphogenesis in utero. Hennessy et al. used 3D facial scans of patients with bipolar disorder, schizophrenia and controls with no history of psychogenic disturbance to determine if facial morphology changes between these groups. Images were obtained of 13 male and 14 female subjects with bipolar disorder and were compared with images from a previous study by Hennessy including 61 male and 75 female controls and 37 male and 32 female individuals diagnosed with schizophrenia. A Polhemus FastScan laser scanner (Colchester, VT) was used to record the images and 24 landmarks, as well as 1694 pseudo-landmarks determined by an automated algorithm, were identified for each image. When bipolar males were compared to controls, they tended to have down-turned noses, a narrow and posteriorly-set mouth, the chin is set forward, the mandible is wide, cheeks are displaced inward, eyes are narrower and the face is wider at tragion. For females, bipolar women exhibit a vertically short and laterally broad face with an upturned nose, wide mouth that is set forward with thinner lips, chin is higher and forward, cheeks are displaced outward and eyes are narrower. When comparing bipolar and schizophrenic subjects, no statistically significant differences were noted with more similarities than differences. The authors conclude that both psychological disorders may reflect a similar etiology with slightly different timing or a slightly different insult at a similar time point in embryologic development.[22] Therefore, 3D surface imaging technology can be applied in many research situations to aid in understanding differences seen in growth and development, between the sexes and differing ethnicities, in people with craniofacial abnormalities and when looking for accompanying facial dysmorphologies with psychogenic disturbances. This technology will continue to be utilized in the future for an increasing numbers of research applications, including the aging of the human face.

Exploration into Variables contributing to Aging

Research in the plastic surgery and dermatology literature shows great interest in the facial aging phenomenon and the variables contributing to aging of the facial soft tissues. Clinicians hope to utilize the information gathered to focus on treatments that aid in the rejuvenation of the adult face, which is becoming a popular request from today's aging patients. To study age-related changes, researchers often employ the use of mother-daughter pairs. See et al. recruited 15 mothers and daughters to obtain scans of their faces in both an upright and supine position using the Vectra-3D system (Canfield Scientific,Fairfield, NJ). Image analysis software plotted 20 landmarks on an x,y,z coordinate system and differences between the mothers and their daughters were recorded. The results showed the most movement in the dorsoventral plane (up to 7.6 mm), up to 7.3 mm in the horizontal plane and 5.7 mm in the vertical plane. However, the dorsoventral plane had no significant movements, whereas the upper lip, lateral canthi, labial commissures and gonial angle moved significantly in the vertical plane. Between the supine and upright positions, the most movement occurred in the middle and lower face, with the mothers showing significantly more movement, especially around the nasolabial fold and marionette lines. The authors of this study argue that skin elasticity and gravity play a role in the aging process and advise clinicians to analyze patients in the supine position, as well as the usual upright position, as fillers and esthetic surgeries are often performed in the supine position and there are significant positional changes of the facial soft tissues.[23] Along with this data, other groups of researchers have also used mother-daughter pairs to examine aging changes.

Camp et al. used 42 mother-daughter pairs of differing ethnicities for comparison when looking at aging of the periorbital tissues. They acquired 3dMD facial images of each participant and sectioned a 35 mm radius around the orbits of each image to isolate the periorbital region. The mother and daughters images were superimposed with the daughter as the base reference. They measured both quantitative and qualitative changes and found periorbital volume loss in the mothers occurred mostly in the superomedial orbit, nasojugal groove and palprebral-malar junction. These findings showing tissue atrophy and volumetric loss in the mothers give researchers and clinicians insight into aging and allow development of tools to rejuvenate these areas.[24] Although orthodontists do not commonly influence the orbital area of the face during treatment, they must be aware of changes that occur with aging and how these can impact orthodontic treatment.

Historically, gravity carried the blame for causing the sagging and drooping of facial soft tissues. Donath et al. decided to examine other factors that also lead to premature aging. They site work by Pessa et al. that states bony remodeling causes a clockwise rotation of the facial skeleton, leading to an undermining of the midface and malposition of the lower eyelid with lateral bowing and an increase of scleral show. Aside from bony changes, muscle and ligaments also relax and stretch over time and skin thins and loses elasticity.

Sun exposure and smoking increase the rate at which the skin deteriorates. However, the main cause of tissue aging continues to be volume loss. Over time, the body undergoes lipoatrophy, where the subcutaneous fat tissue disappears and loss of colloidal fluid in the skin results in cutaneous aging. The authors elaborate on methods of skin rejuvenation for aging patients to increase the lost volume and assert that understanding of the aging process allows for creation of newer and better techniques to achieve natural results.[25] In addition to the factors listed above, Sherris et al. review other elements in the aging equation. They review the aging face syndrome, which is defined as *"the dynamic, cumulative and degenerative effects of aging on both the superficial and structural integrity of the face"*. The authors divide these variables into two factions: intrinsic and extrinsic. Intrinsic aging includes genetic background and health considerations, whereas extrinsic aging takes into account the individual's environment, history of sun exposure and history of cigarette smoking. Prevention of premature aging through sunlight protection and avoidance of tobacco are advocated and the topic of rejuvenation accomplished through plastic surgery techniques are discussed by the authors as well.[26] Although the orthodontist has a reduced opportunity to reverse the facial aging process than does a plastic surgeon, the concept of aging remains important to orthodontic patients and every attempt at preventing premature aging through poor treatment planning should be avoided.

Facial Morphology Differences between African Americans and Caucasians

Currently, orthodontic practitioners can expect to encounter a multitude of patients with differing ethnicities and backgrounds seeking treatment. When attempting to determine the best treatment plan for optimum esthetics, ethnic and cultural norms may play a role in how an orthodontist chooses to treat a particular patient. Multiple studies have shown the variability in facial features seen between ethnicities. In terms of differences in facial morphology between African Americans and Caucasians, Sushner looked at profile photographs of 1000 young African American subjects and compared the measurements of their Holdaway H-line, Steiner S-line and Ricketts esthetic line to the previously found Caucasian norms.[27] He found that the African American subjects were more protrusive in all measurements. The author concludes that facial harmony and norms vary between races; the Caucasian norms should not be used when treatment planning for African American patients and he offers new soft tissue norms for African American patients. Due to the increased likelihood of a protrusive profile, Caplan and Shivapuja looked at how premolar extractions affects the facial profile of adult African American patients. [28] Their sample consisted of 28 adult African American female patients with clinically diagnosed soft tissue bimaxillary protrusion. In accordance with the chief complaint and clinical diagnosis, four premolars were extracted on each patient to attempt to decrease the amount of soft tissue protrusion. This study retrospectively looked at how incisor retraction affects lip protrusion and found that significant retraction of both lips occurred with treatment, the nasiolabial angle became more obtuse while the mentolabial sulcus did not change and both lips appeared to become thicker. The ratio of lower incisor retraction to lower lip retraction was 1.2:1 and upper incisor retraction to upper lip retrusion was 1.75:1. The authors concluded that although many factors play a role in the interaction of hard tissue changes with concomitant soft tissue changes, extraction of four bicuspid teeth did result in significant soft tissue profile changes in these patients. Therefore, in select cases, the use of extraction therapy to reduce protrusiveness of the soft tissue profile may result in favorable outcomes in the non-growing African American female population.[28]

In an editorial article, Haskell and Segal discussed the challenges in treatment planning for diverse populations by saying,

"*As practitioners we must be aware of certain distinct ethnic dental and skeletal traits, since being knowledgeable often allows for wiser and speedier treatment choices. These may include distinctions as to whether or not a patient requires extraction, orthognathic correction, or perhaps even a cheiloplasty. Works other than this commentary enumerate physical distinctions of differing ethnic groups, including such factors as: convexity, incisal angulation, dental and soft tissue contouring and protrusion, skeletal vertical dimensions, inherent orientation to Class II or III malocclusions, etc.*"[29]

While the authors continue on to state that treatment decisions should not be based on ethnic classifications alone, but should include the chief complaint and social ideologies of the individual patient, it is important for orthodontic to be aware of the continuum of facial features they are treating.

Aging of the African American Female Population

From previous research, it becomes evident that facial soft tissue changes do occur over time and these changes create challenges in treatment planning for orthodontists. Also, gender and ethnicity play a role in soft tissue facial aging as well. Within the African American female population, not much literature exists in the orthodontic arena, but most research has been in the fields of dermatology and plastic surgery. De Rigal et al. looked at how aging affects skin color and skin heterogeneity between different ethnic groups. Their sample included 385 female subjects of African American, Caucasian, Chinese and Mexican descent. These subjects were divided into age ranges and had the skin on their forehead and cheek analyzed with the Chromasphere, a device that was developed to measure skin color on the face. They found that the forehead is darker, less red and more yellow than the cheek in all ethnicities, the cheek shows more heterogeneity and that the skin darkens over time in all ethnicities. African Americans showed the most skin heterogeneity in younger ages but showed significantly less heterogeneity with aging. The authors concluded that the skin of African American subjects is affected less by aging than other ethnicities.[30]

Although African American females tend to show less aging of the skin of the face, there remains a demand for esthetic procedures to reverse the aging process. However, many adults yearn for less invasive procedures than were historically performed. Monte Harris discussed minimally invasive surgical facial rejuvenation for females of color. He notes that in this population some facial areas age prematurely, whereas others show a delay in the process. The upper face tends to age less in African American females with a decrease in brow ptosis compared to Caucasian females. However, African American females complain of upper eyelid fullness, dark circles and bags under the eyes and wrinkles. In terms of the midface, he states that aging occurs prematurely for this population of women. The malar fat pad atrophies and drops, the infra-orbital region appears hollower and the nasiolabial fold deepens. The author asserts that this results from infra-orbital hypoplasia, even in a population that typically presents as skeletally bimaxillary protrusive. In addition to the deficient midface, heavy skin with a thick dermis and subcutaneous tissue may weigh down the area, leading to early aging. As with the upper facial area, the lower face also tends to show a delay in aging and jowling in the African American female population. The author speculates that the heavy skin helps in this area by preserving elasticity in the submental area. Overall, this population seems to show less pronounced aging of the upper and lower face than the Caucasian female population, but an increase in mid-facial aging, which can be addressed by plastic surgeons in a minimally invasive way.[31]

Research on aging of the African American female face proves important for orthodontists treating multiple ethnicities, especially in the state of Alabama. According to the 2013 census, African Americans represent 26.5% of the population and females make up 51.5% of Alabamians.[32] Therefore, most orthodontists in Alabama and the south can expect to treat a fair number of African American adult females during their careers. Understanding the differences in aging between African American and Caucasian females will aid in optimal treatment planning to provide an esthetic result to this population of patients. Hence, the need for this study.

CHAPTER 2

AIMS OF THE STUDY AND HYPOTHESES

Aims

The aims of this study are to: (1) examine soft tissue facial aging in the African American female subpopulation, and (2) compare this to previously found data on aging of Caucasian females.

Hypotheses

The null hypotheses of this study are: (1) Soft tissue aging of the African American female face is a continuous process, and (2) there are no differences in facial aging between age-specific subgroups of African American females and Caucasian females.

CHAPTER 3

MATERIALS AND METHODS

This study is designed as a cross-sectional study looking at the facial aging of African American females using three-dimensional surface imaging technology. The subjects were recruited from a population of women in Birmingham, Alabama. 100 subjects were divided into five groups dependent on age: 20-30, 31-40, 41-50, 51-60, 61-70. This number reflects previous recruitment of a Caucasian female population. Each age grouping contains 20 subjects. The UAB Institutional Review Board for Human Use granted approval for this study.

Subject Selection Criteria

- Subjects must be female
- Subjects must be African American
- Subjects having no major skeletal deviations, craniofacial syndromes or history of craniofacial trauma and no need for orthognathic or reconstructive facial surgery
- Subjects have not received injectables such as Botox or any fillers
- Subjects' have a body mass index (BMI) of 18.5-32 (calculated from height and weight)

Image Acquisition

Three-dimensional surface images of each subjects face will be gathered using the 3dMDface^{TM} system (3dMDface, Atlanta, GA). This system combines the structured light and stereo-photogrammetry techniques and consists of two camera boxes, each containing three lenses (one color and two infrared) working in stereopairs. It is capable of capturing facial images from ear to ear and under the chin to the neck in 1.5 ms at the highest resolution. The manufactures accuracy is recorded as <0.5 mm and the clinical accuracy is 1.5% (as previously mentioned above).

Procedure

If the subject fulfills the inclusion criteria, she is given information on the study and any questions are answered. The subject reviews and signs the informed consent. If the subject does not wish to participate, she is free to leave. The participant is assigned a number based on her designated age group. She is seated in front of the machine on an adjustable stool and is asked to hold her head in a comfortable, natural head posture. The picture is taken and checked for quality and if needed, the picture is retaken. It is subsequently stored according to the assigned number on a secure server at the UAB School of Dentistry. The entire process takes five to ten minutes. The participant receives a $10 Visa gift card for her time.

Data Analysis

Each image is saved according to the age group of the participant and sequential numbering. The 125 images can be accessed on a secure server and loaded into the 3dMDvultus facial software platform for analysis. 28 specific facial landmarks are plotted on each image (Table 1). Figure 1 shows the landmarks plotted on an individual image.

Figure 1

Example of Plotted Soft Tissue Landmarks on Individual Face

Table 1.
Plotted Soft Tissue Landmarks

Median Landmarks	**Bilateral Landmarks**
Glabella	Endocanthion
Nasion	Exocanthion
Pronasale	Orbitale
Subnasale	Alare
Labiale Superius	Subalare
Stomion	Cristi Philtri
Labiale Inferius	Chelion
Pogonion	Porion
Gnathion	Zygion
Chin-throat	

Nasion is set as the base reference (0,0,0) and all other points are calculated on an x,y,z coordinate system in relation to nasion. The plotted points are averaged (means and standard deviations collected) for each age group and then comparisons are made between age groups looking for significant trends. The African American female age groups are also compared to the corresponding Caucasian female age groups (data previously collected by the Principal Investigator) to garner information on differences in aging between these two ethnic groups.

Statistical Analysis

For each ethnic group, means and standard deviations of distances from Nasion (origin) to all landmarks were calculated for each group. A Shapiro-Wilk test was used to determine normality for all measures, and measures were compared across the five age groups for each ethnic group separately using an ANOVA test. Pairwise comparisons utilizing Tukey's honest significance test (to account for multiple comparisons) were performed when the overall model ANOVA F-test was statistically significant. A general linear model with an interaction between ethnic group and age group was used to determine whether the ANOVA association between age group and facial feature distance varied by ethnic group. For all comparisons, a $p<0.05$ was considered statistically significant and SAS version 9.3 was used. Inter and intra-examiner reliabilities for the African American faces were calculated by plotting the landmarks twice on 5 faces, one from each group, at 5 days intervals. The mean value of each distance was used to estimate reliability through use of an intraclass correlation.

CHAPTER 4

RESULTS

Among the African American female population, significant differences ($p<0.05$) by age groups were observed for the mean distances from Nasion to the soft tissue median points Pronasale, Subnasale, Labiale Superius, Stomion and the chin-throat point and the bilateral points Orbitale, Alare, Subalare, Christi Philtri, Cheilon and Zygion (Table 2). Around the eyes, the right and left exocanthion points tended to elongate (compared with nasion) with differences seen between the 31-40 age group and the 61-70 age group. The left and right orbitale points also tended to descend over time, with significant differences between the 61-70 group with each age group. Around the nose, pronasale and subnasale showed significant changes in the 61-70 age group versus all other groups, with a generalized trend of drooping of the tip of the nose over time. Right and left alare changed significantly in the 61-70 year old group compared with all groups except 41-50. Right and left subalare dropped significantly between the 20-30 and 61-70 age groups. On the upper lip, labial superius and right and left cristi philtri changed significantly between the second decade with the 41-50 and 51-60 age group and showed significant differences for the 61-70 age group versus all other age groups, indicating the upper lip starts aging in the fifth decade In terms of the lower facial region, African American women showed a drooping of right and left chelion, as well as for stomion, between the 20-30 year old group and the 61-70 group. The chin-throat point showed changes between the first three groups and the 61-70 year olds, showing a jowling effect beginning in the seventh decade of life. The zygion point on the right and left cheekbones showed changes starting in the 51-60 age group compared with women in the 20-30 and 31-40 age groups.

Table 2.
Comparison of facial feature distances from nasion by age group among African-American females

	20-30	31-40	41-50	51-60	61-70	p-value*
Glabella	14.4±2.7	13.9±1.6	13.8±2.0	13.4±1.7	14.3±3.0	0.7013
Right Endocanthion	20.8±1.5	21.7±2.2	21.5±2.0	21.2±1.6	22.1±2.2	0.2141
Left Endocanthion	21.9±1.6	23.2±2.3	23.0±1.7	22.5±1.6	23.1±2.5	0.2241
Right Exocanthion	50.9±2.2	51.4±2.2	51.0±2.3	51.0±2.0	49.2±2.1	0.0127*
Left Exocanthion	50.8±3.0	52.3±2.9	51.1±2.5	51.1±2.3	49.0±3.0	0.0099*
Right Orbitale	42.9±2.1	45.2±2.3	46.2±2.5	47.5±2.6	49.2±2.5	<0.0001*
Left Orbitale	45.6±3.1	46.8±2.6	47.6±3.0	48.0±2.2	49.2±3.5	0.0034*
Pronasale	38.1±2.7	40.0±3.8	41.2±3.7	40.7±3.1	44.2±3.6	<0.0001**
Subnasale	47.2±3.0	48.6±3.3	49.1±3.8	48.2±3.0	51.5±3.1	0.0013*
Right Alare	45.0±2.4	46.3±3.3	46.7±3.3	46.1±2.9	49.0±3.0	0.0014*
Left Alare	44.8±2.5	47.0±3.2	47.0±3.5	46.2±3.0	48.9±2.8	0.0015*
Right Subalare	46.7±2.5	48.1±3.3	48.2±3.8	47.5±3.0	49.9±3.1	0.0295*
Left Subalare	46.6±2.9	48.4±3.4	48.3±3.6	47.8±2.8	50.3±2.8	0.0080*
Labiale Superius	62.1±3.8	65.4±4.8	66.9±4.5	66.3±3.0	70.3±3.7	<0.0001*
Right Cristi Philtri	60.7±3.8	64.0±4.7	65.7±4.4	65.0±2.7	69.2±3.5	<0.0001*
Left Cristi Philtri	60.7±3.8	64.1±4.6	65.7±4.5	65.0±2.9	69.3±3.7	<0.0001*
Stomion	71.5±3.9	73.9±4.9	74.2±4.4	73.6±2.7	76.6±3.9	0.0038*
Labiale Inferius	83.9±4.5	85.7±6.2	85.3±5.2	84.0±3.0	85.7±4.4	0.5705
Right Cheilon	75.4±3.3	77.3±4.7	78.0±4.0	77.6±2.4	80.4±3.9	0.0017*
Left Cheilon	75.3±3.4	77.6±4.4	77.8±4.6	77.5±2.4	80.2±3.9	0.0036*
Pogonion	101.7±5.4	103.7±6.7	105.3±.3	103.8±3.4	106.1±4.5	0.1085
Gnathion	110.6±6.8	111.5±7.1	112.7±6.8	111.5±3.8	113.6±4.8	0.5658
Chin-Throat point	130.4±8.3	131.7±6.7	134.4±8.2	137.8±6.7	141.5±9.4	<0.0001*
Right Porion	119.7±8.4	121.4±4.4	122.3±4.9	121.0±10.1	121.4±5.1	0.8177
Left Porion	120.2±7.1	121.0±5.3	122.4±4.7	121.0±7.6	121.5±6.2	0.8414
Right Zygion	75.6±4.5	78.3±4.9	80.1±4.1	83.5±3.9	83.3±3.2	<0.0001*
Left Zygion	74.0±4.7	75.4±4.4	77.4±4.3	80.9±3.4	80.7±5.9	<0.0001*

* Based on an analysis of variance (p<0.05)

Soft tissue points in Caucasian women previously collected were used were used for direct comparison of the differences in soft tissue aging between the races (Table 3). Caucasian women exhibited changes in the midface, with the significant changes in the right and left orbitale points between the 61-70 age group and other age groups. The 51-60 age group also showed a difference from the 41-50 group, indicating that the under-eye area tends to start sagging noticeably in the sixth decade. The left zygion point on the cheekbones showed a borderline significance in the ANOVA for the 51-60 age group compared to the 30-41 group, whereas the right zygion was not significant. For the nasal region of the midface, pronasale, subnasale, right and left alare and right and left subalare showed significant changes between the 61-70 age group and the younger age groups. All points excluding pronasale also showed an increase in length from nasion starting in the 51-60 age group. As for the lips, labiale superius, right and left cristi philtri, stomion and right and left chelion all showed changes in the 61-70 age group versus other age groups. The 51-60 age group also exhibits significant changes compared to the 41-50 and younger groups. The point labiale inferius began to show changes in the 41-50 age group, as compared to the youngest group. In the lower face and chin, significance was noted in the pogonion and gnathion region at 61-70 versus 41-50 and at 51-60 versus 41-50. The chin-throat point showed significance in the ANOVA but did not yield any significant results in the pairwise comparison.

Table 3.
Comparison of facial feature distances from nasion by age group among Caucasian females

	20-30	31-40	41-50	51-60	61-70	p-value*
Glabella	17.1±2.9	17.5±2.8	18.4±2.3	17.7±3.6	18.6±3.5	0.4217
Right Endocanthion	22.9±1.4	22.9±2.2	22.1±1.8	22.2±2.4	23.7±2.5	0.0594
Left Endocanthion	23.7±1.6	22.9±2.0	22.6±1.5	22.7±2.1	23.9±2.5	0.0759
Right Exocanthion	49.1±1.6	49.8±3.0	48.7±3.0	48.5±2.2	47.9±2.6	0.1329
Left Exocanthion	49.4±1.8	49.3±3.0	48.7±2.7	48.7±1.6	47.5±2.3	0.0689
Right Orbitale	40.7±2.0	41.3±2.6	40.4±2.6	42.0±2.5	43.0±2.3	0.0031*
Left Orbitale	42.2±2.0	42.7±2.5	42.1±2.7	44.2±.5	45.3±2.1	<0.0001*
Pronasale	43.4±3.4	43.2±3.3	41.8±3.9	44.3±3.5	45.1±4.4	0.0378*
Subnasale	49.1±3.4	47.9±2.7	47.0±3.1	50.2±3.5	51.4±2.9	<0.0001*
Right Alare	45.3±2.7	44.6±2.9	43.4±2.4	46.5±3.3	47.5±2.6	<0.0001*
Left Alare	45.5±3.1	44.8±2.6	44.0±2.6	46.5±3.2	47.3±2.7	0.0013*
Right Subalare	48.5±3.0	47.4±2.8	46.1±2.4	49.3±3.2	50.5±2.7	<0.0001*
Left Subalare	48.5±2.1	47.8±2.7	46.5±2.5	49.5±3.2	50.3±2.9	0.0001*
Labiale Superius	65.0±3.3	65.1±3.4	64.3±3.5	68.2±3.9	70.5±4.4	<0.0001*
Right Cristi Philtri	63.9±3.2	63.7±3.5	63.2±3.3	67.3±3.5	69.6±4.3	<0.0001*
Left Cristi Philtri	63.9±3.4	64.0±3.2	63.3±3.4	67.4±3.5	69.8±4.3	<0.0001*
Stomion	69.8±3.4	69.7±3.4	68.1±3.4	72.5±4.1	73.9±4.5	<0.0001*
Labiale Inferius	78.1±3.8	76.7±3.8	73.9±4.0	77.8±5.0	78.3±5.4	0.0018*
Right Cheilon	75.5±2.8	75.3±3.7	73.6±3.4	77.3±4.4	78.3±4.2	0.0002*
Left Cheilon	75.3±3.0	75.3±3.4	73.9±3.6	77.4±4.1	78.4±4.3	0.0003*
Pogonion	99.3±3.4	100.4±5.0	98.0±4.9	102.1±4.8	102.4±6.2	0.0101*
Gnathion	107.0±3.1	108.1±4.9	105.9±4.8	110.0±4.7	110.8±6.4	0.0031*
Chin-Throat point	124.8±5.6	124.9±7.0	125.1±7.3	121.8±8.8	119.3±8.9	0.0412*
Right Porion	117.0±4.1	118.8±4.6	118.2±4.5	120.2±4.8	118.6±4.1	0.1703
Left Porion	117.3±3.9	119.2±4.3	117.6±4.7	119.2±4.1	118.2±4.6	0.4002
Right Zygion	70.9±3.0	70.9±3.9	69.5±3.4	68.2±3.2	68.3±3.1	0.0083*
Left Zygion	72.1±4.1	69.6±4.0	71.1±4.1	71.0±2.9	69.4±.4	0.0898

* Based on an analysis of variance (p<0.05)

Table 4 compares the results of the ANOVA between age groups for African American and Caucasian females in columns 1 and 2, respectively. The slopes of the equations of the Caucasian and African American female regression models were compared looking for significant differences between the two ethnicities. Statistically significant interactions are illustrated in Figures 2 through 18.

Table 4.
Comparison of association between age group and facial feature distance from nasion between ethnic groups.

	p-value$_{AA}$	p-value$_{C}$	p-value$_{INT}$
Glabella	0.7013	0.4217	0.5086
Right Endocanthion	0.2141	0.0594	0.4322
Left Endocanthion	0.2241	0.0759	0.0470*
Right Exocanthion	0.0127	0.1329	0.7462
Left Exocanthion	0.0099	0.0689	0.5774
Right Orbitale	<0.0001	0.0031	0.0004*
Left Orbitale	0.0034	<0.0001	0.4183
Pronasale	<0.0001	0.0378	0.0117*
Subnasale	0.0013	<0.0001	0.0129*
Right Alare	0.0014	<0.0001	0.0165*
Left Alare	0.0015	0.0013	0.0155*
Right Subalare	0.0295	<0.0001	0.0074*
Left Subalare	0.0080	0.0001	0.0241*
Labiale Superius	<0.0001	<0.0001	0.0093*
Right Cristi Philtri	<0.0001	<0.0001	0.0034*
Left Cristi Philtri	<0.0001	<0.0001	0.0040*
Stomion	0.0038	<0.0001	0.0153*
Labiale Inferius	0.5705	0.0018	0.0218*
Right Cheilon	0.0017	0.0002	0.0357*
Left Cheilon	0.0036	0.0003	0.0624
Pogonion	0.1085	0.0101	0.1036
Gnathion	0.5658	0.0031	0.2126
Chin-Throat point	<0.0001	0.0412	<0.0001*
Right Porion	0.8177	0.1703	0.7344
Left Porion	0.8414	0.4002	0.6235
Right Zygion	<0.0001	0.0083	<0.0001*
Left Zygion	<0.0001	0.0898	<0.0001*

* Based on an analysis of variance ($p<0.05$)- INT= interaction, AA= African American, C= Caucasian

Around the eyes, left endocanthion showed a slight significance in the Caucasian population (Figure 1). However, right orbitale shows a significant lengthening in all age groups in African Americans as compared to the Caucasian population (Figure 2). In the cheekbone area of the midface, right and left zygion show significant differences in the AA and Caucasian populations. For AA's the zygion continues to increase in length linearly over time, whereas the Caucasian group shows a trend of decreasing length (Figure 3,4). In the nasal area, pronasale continues to drop in Caucasians more than in African Americans (Figure 5) and subnasale to nasion lengthens more in Caucasians in the 51-60 and 61-70 age groups (Figure 6). Right and left alare begin to sag in African Americans in the 31-40 group and show more lengthening in all age groups, whereas these points in Caucasians don't show change until the 51-60 age group (Figure 7,8). For right and left subalare, Caucasians show a significant lengthening beginning in the fifth decade, whereas AA's don't show a difference until the 61-70 age group; however, the Caucasian women showed more change overall (figure 9,10). Around the lips, labiale superius (Figure 11), as well as right and left cristi philtri (Figure 12,13), tend to lengthen in AA's earlier in the 31-40 age group, with Caucasians catching up in the 51-60 age group. Right chelion was significant between races, although left chelion was not. AA's tended to have more lengthening of right chelion overall (Figure 14). For the stomion point, the values are longer in all age groups for AA's, indicating a thicker upper lip. Both races show a lengthening in the 51-60 age groups (Figure 15). Labial inferius does not show a significant change over time for either race, but AA's tend to have a longer distance to labiale inferius due to the tendency for larger lips than Caucasians (Figure 16). As for the chin-throat distance, the length tended to decrease with age and in AA's, the chin-throat point sagged significantly over time in a linear fashion (Figure 17).

Intraexaminer reliability was over 0.7 and intra-examiner reliability was over 0.9 for most plotted landmarks in the African American faces in this study.

Figures 2-18 demonstrate the slopes of the equations of the Caucasian and African American female regression models for each statistically significant soft tissue landmark comparison.

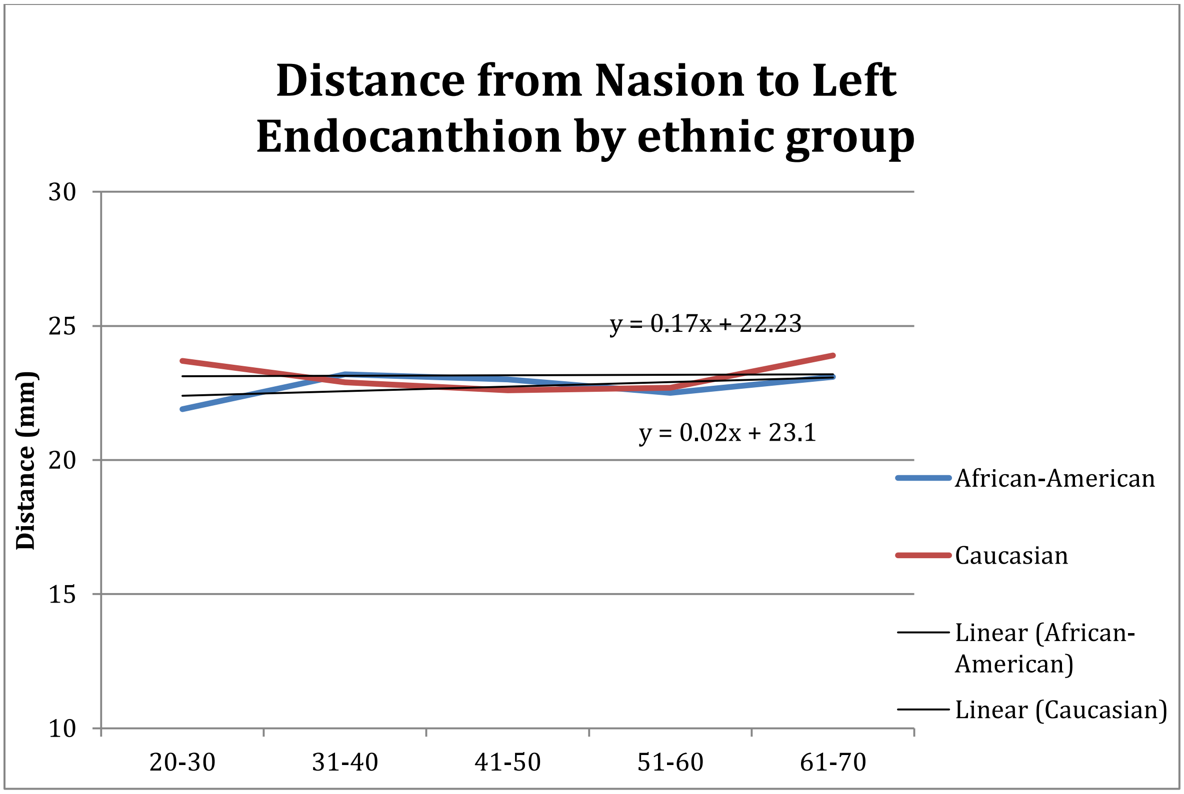

Figure 2: Nasion to Left Endocanthion

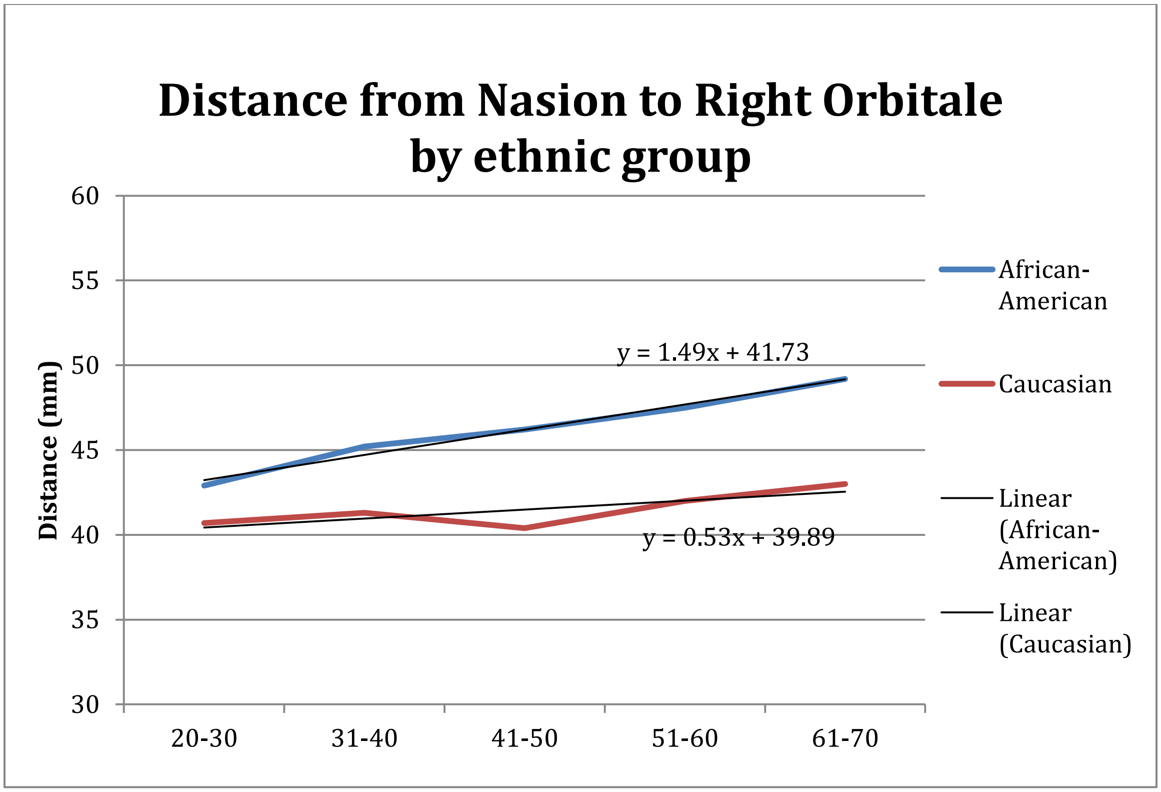

Figure 3: Nasion to Right Orbitale

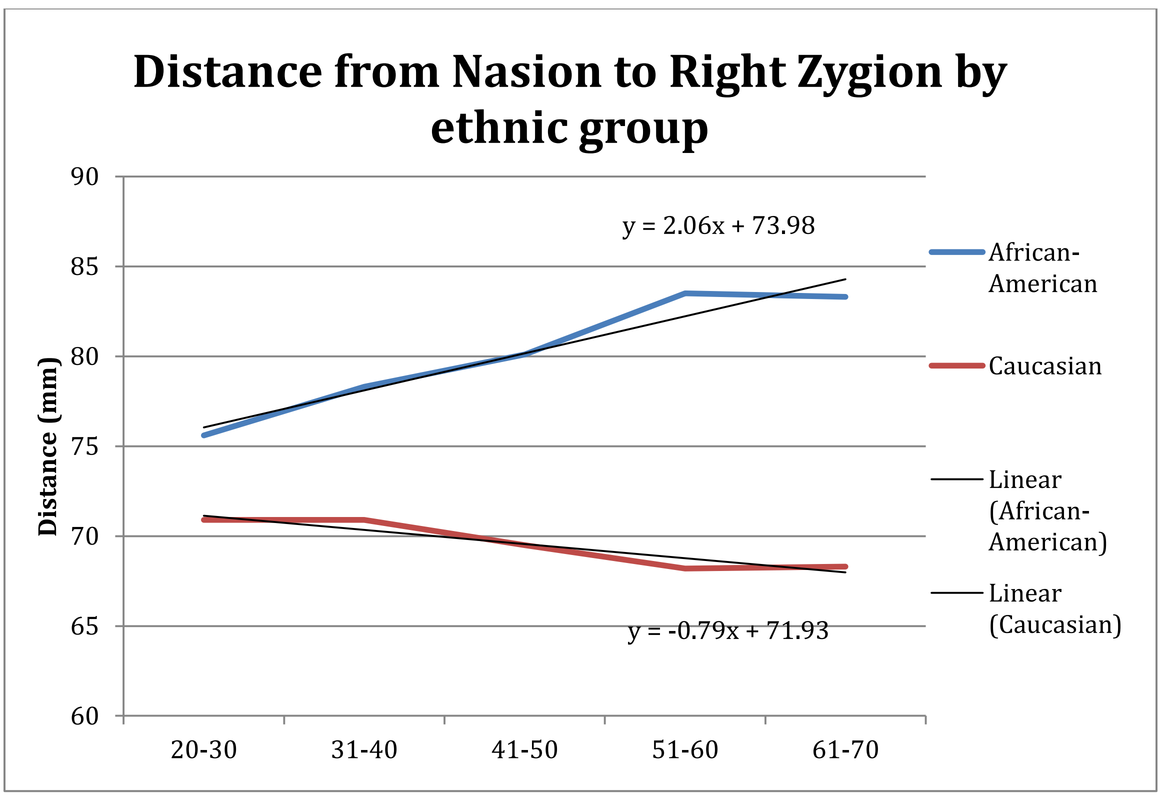

Figure 4: Nasion to Right Zygion

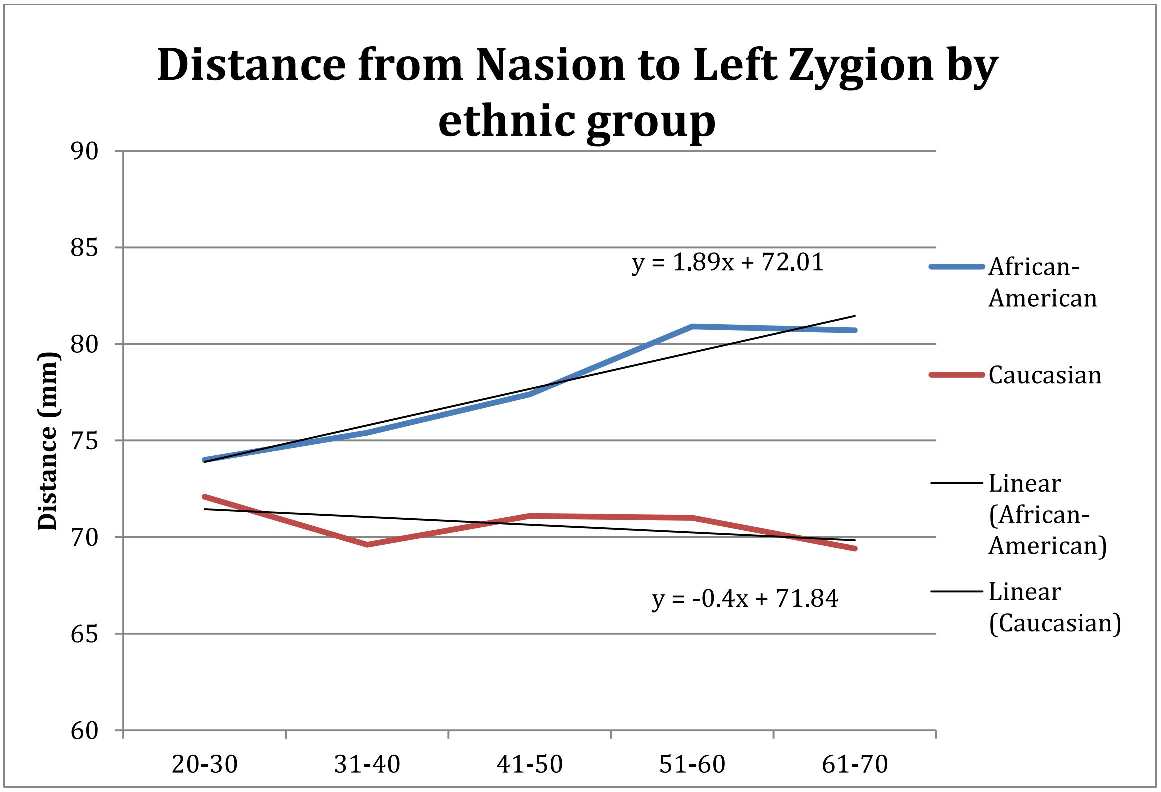

Figure 5: Nasion to Left Zygion

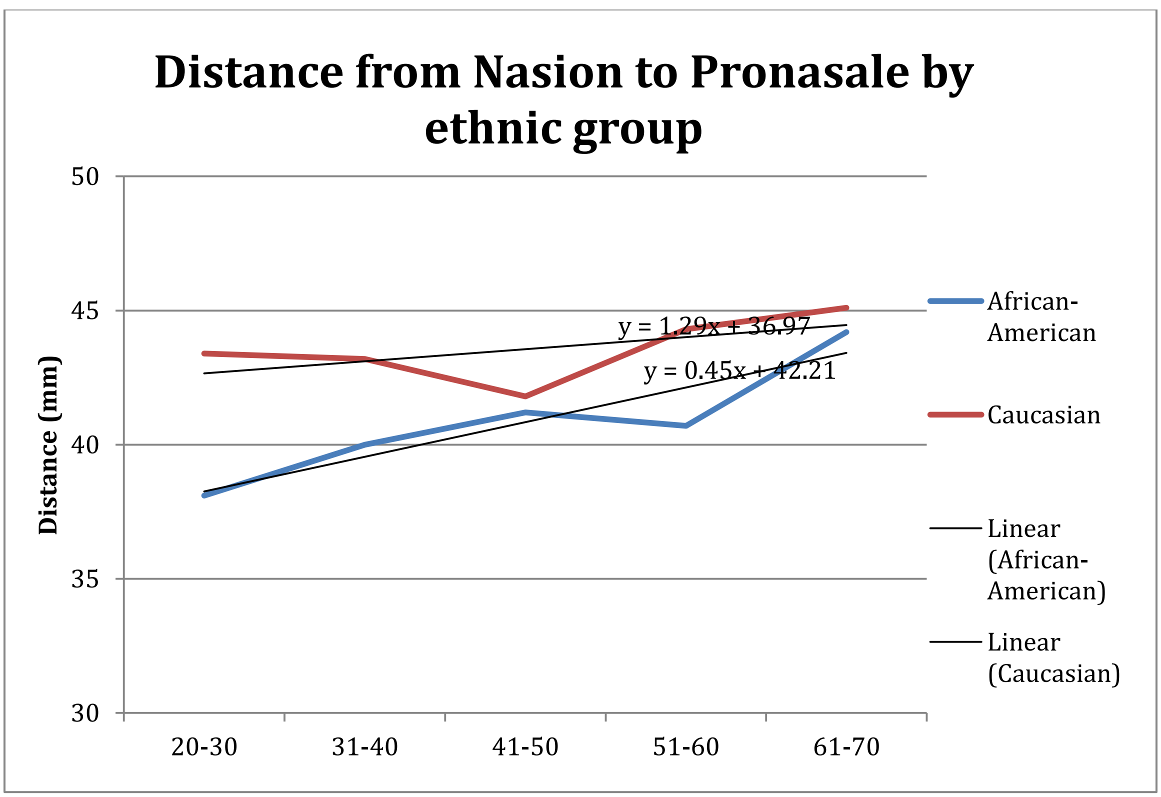

Figure 6: Nasion to Pronasale

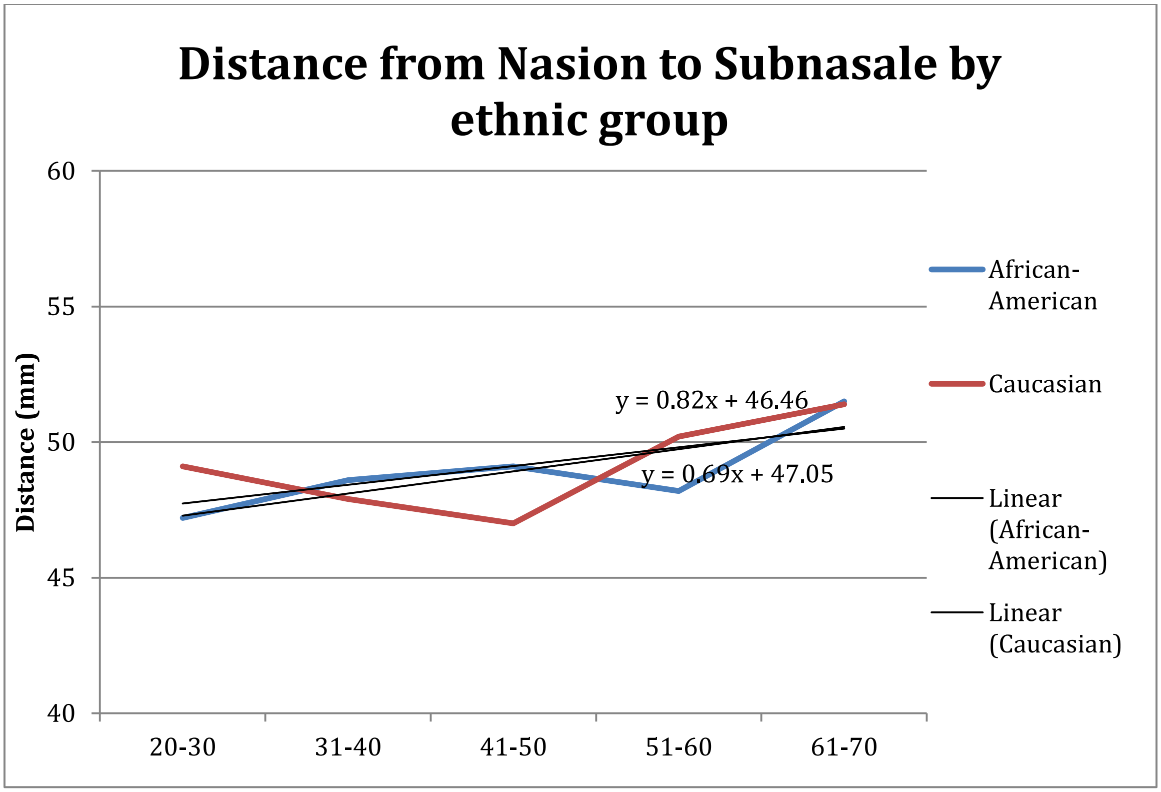

Figure 7: Nasion to Subnasale

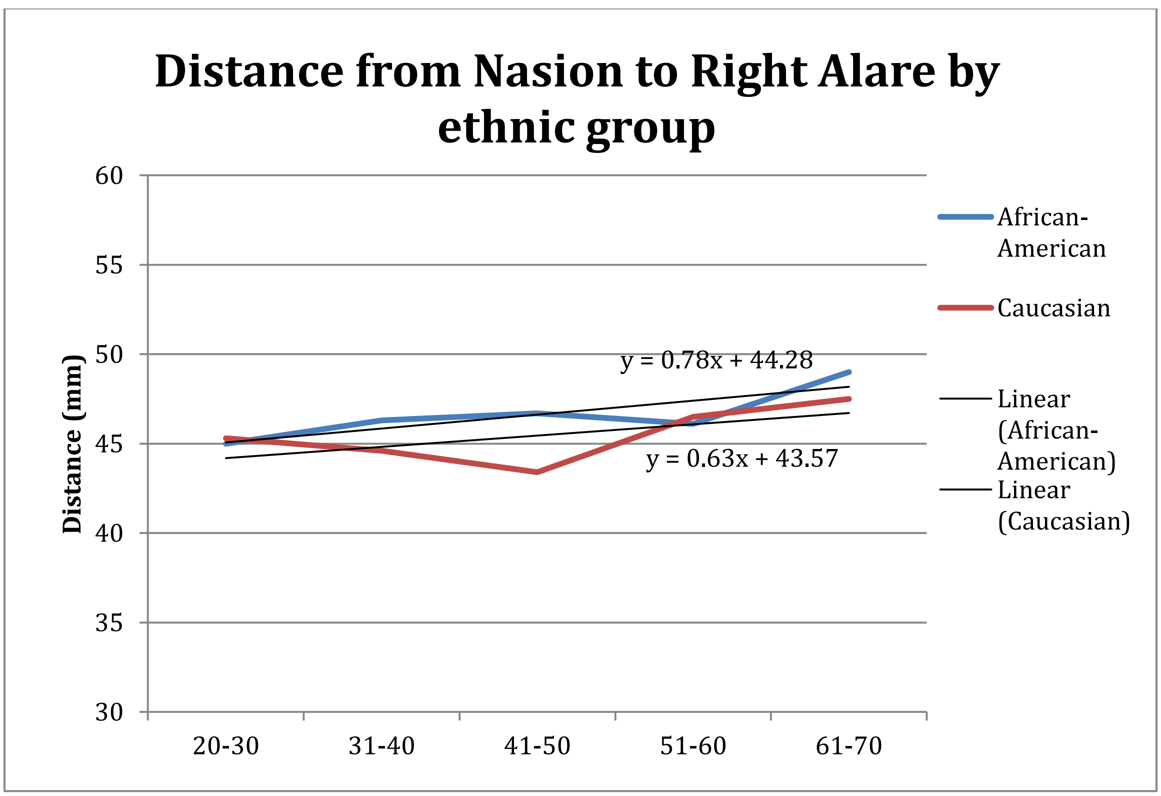

Figure 8: Nasion to Right Alare

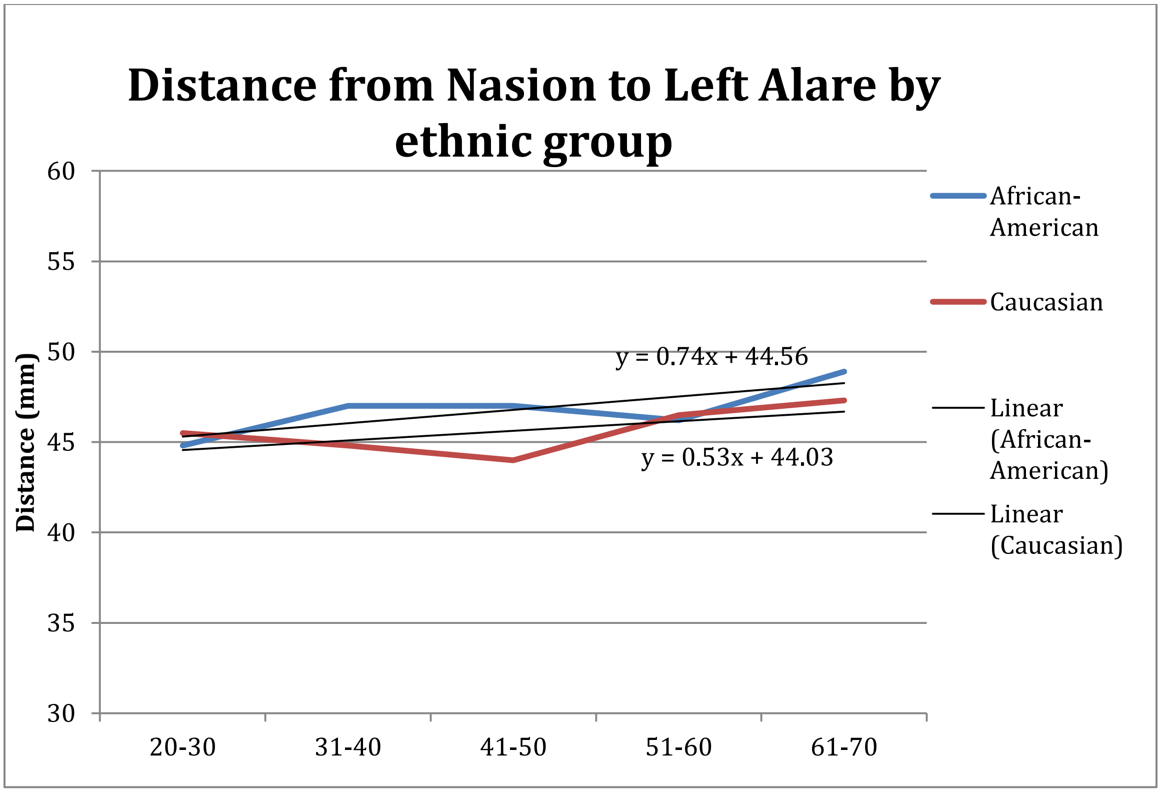

Figure 9: Nasion to Left Alare

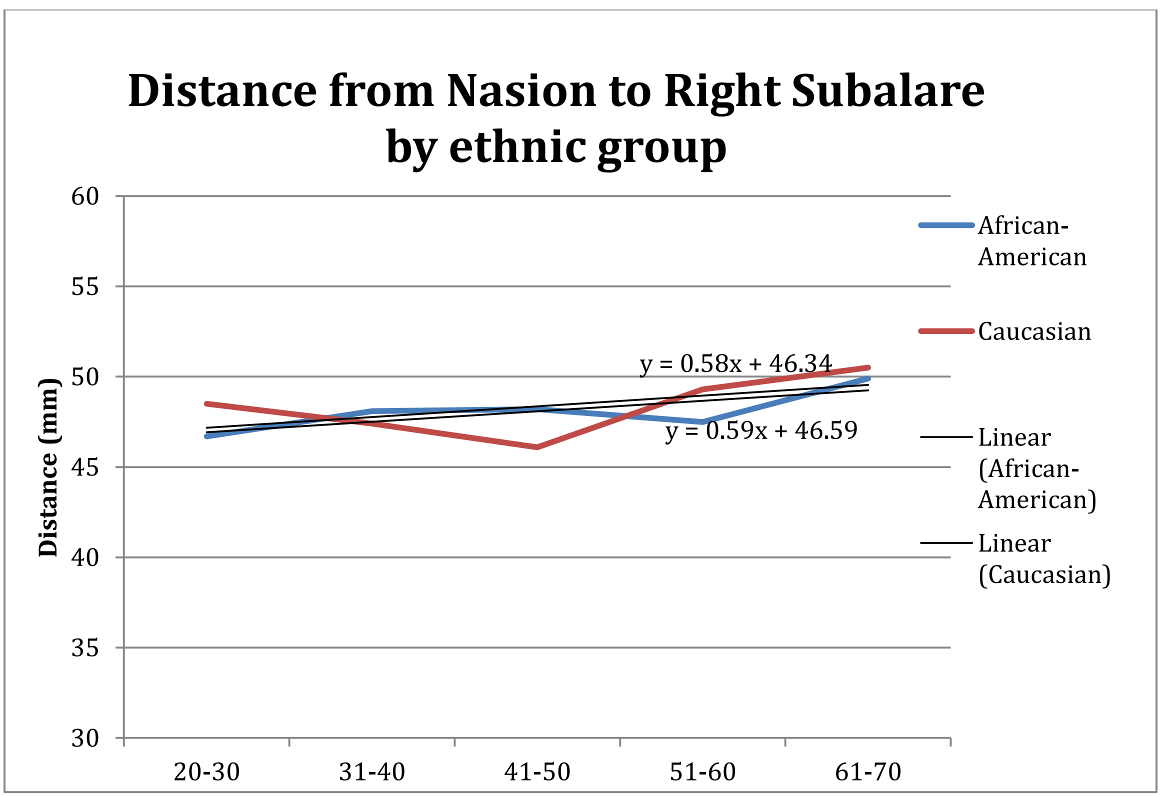

Figure 10: Nasion to Right Subalare

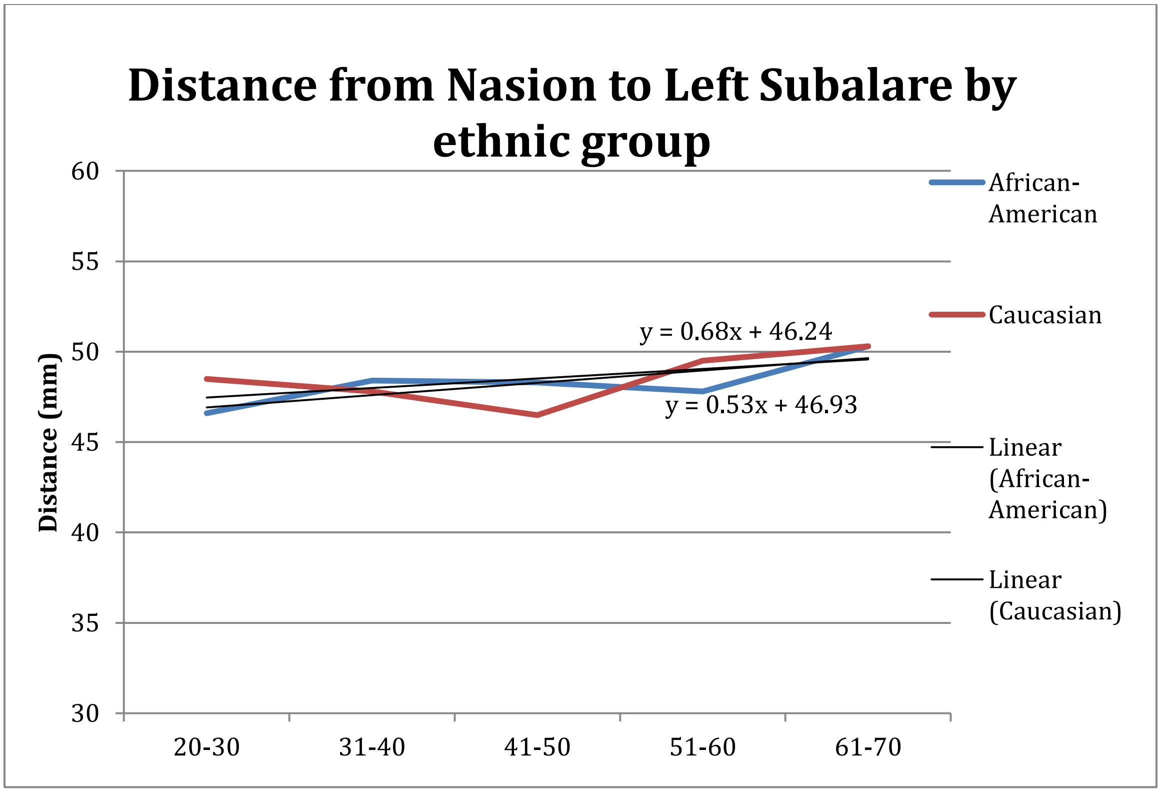

Figure 11: Nasion to Left Subalare

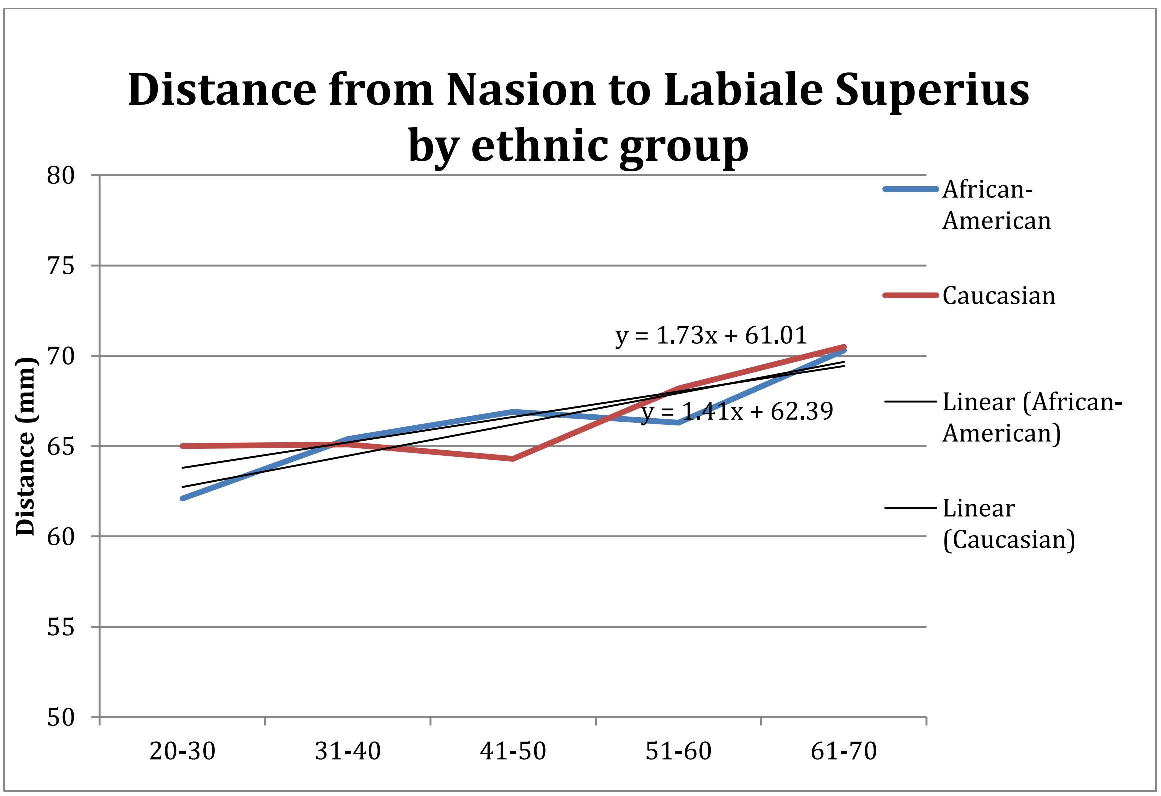

Figure 12: Nasion to Labiale Superius

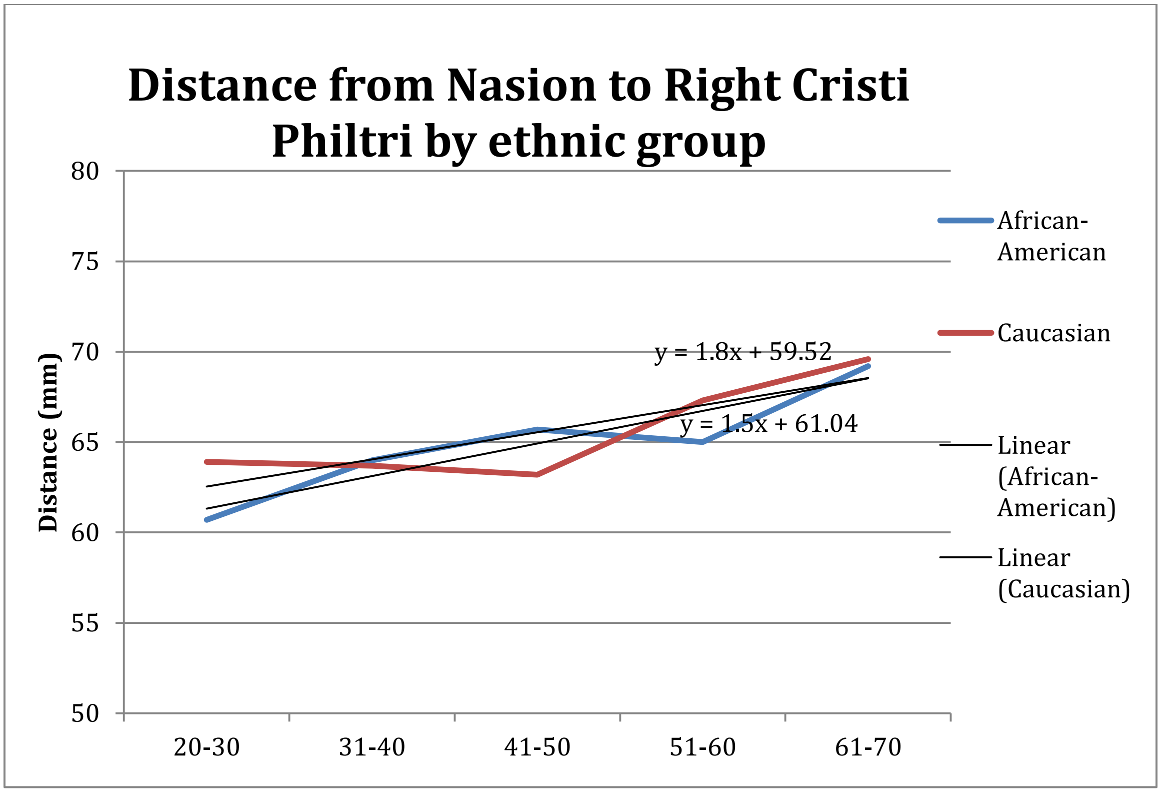

Figure 13: Nasion to Right Cristi Philtri

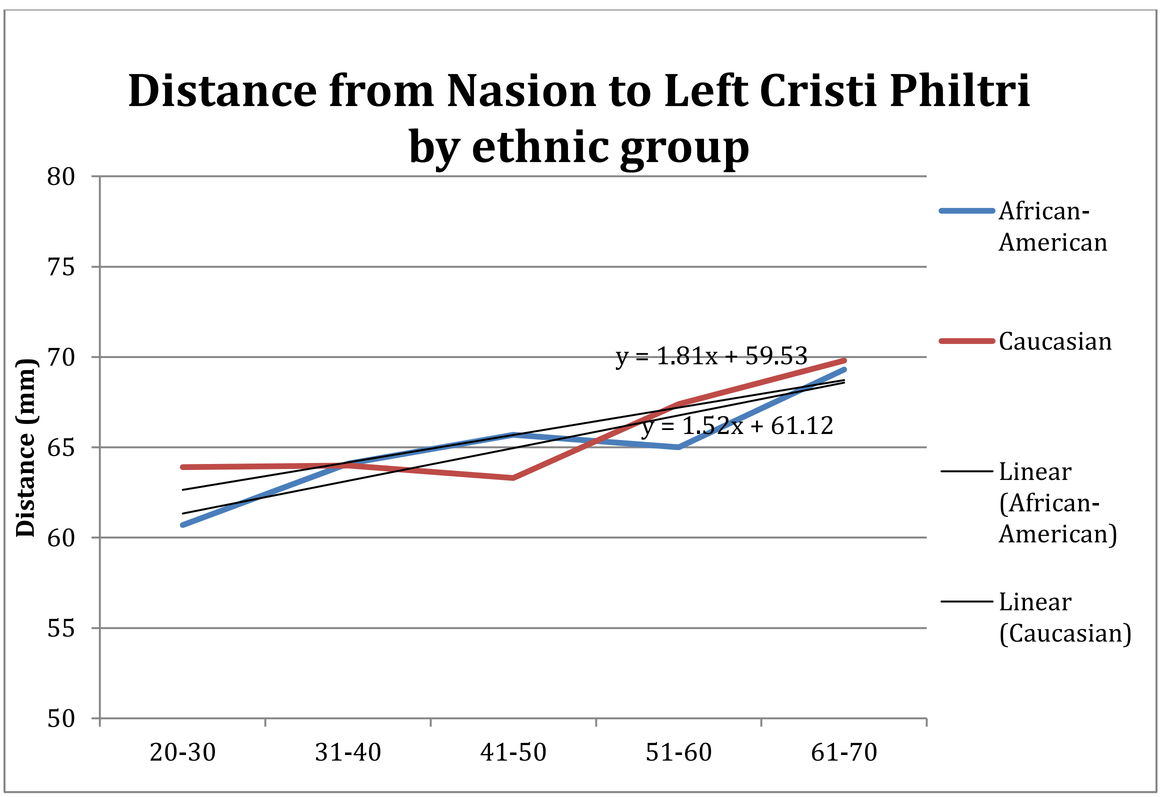

Figure 14: Nasion to Left Cristi Philtri

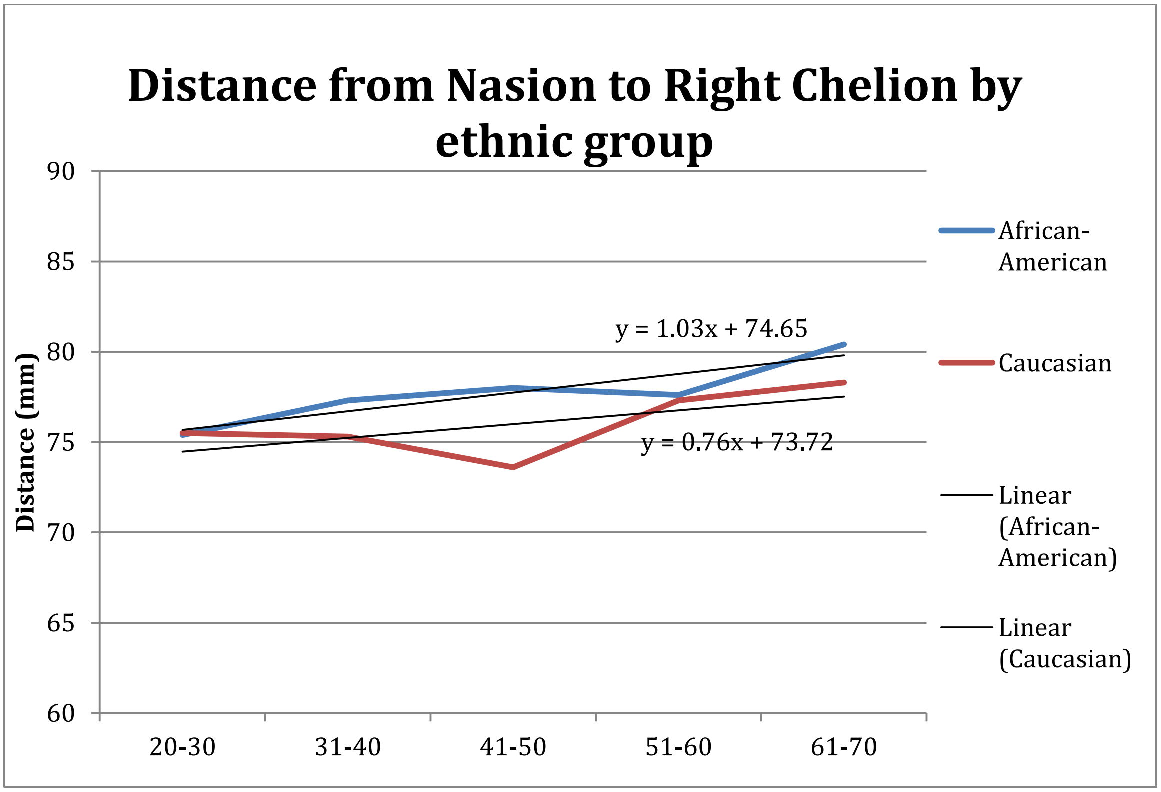

Figure 15: Nasion to Right Chelion

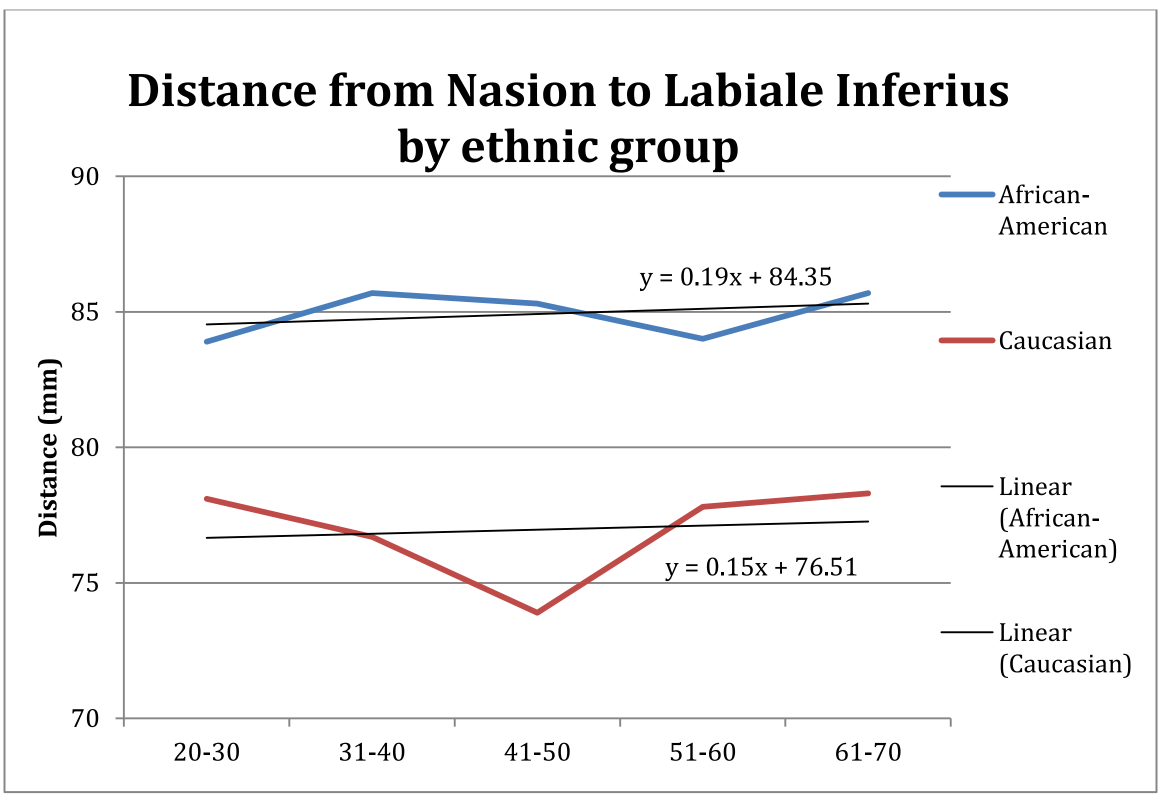

Figure 16: Nasion to Labiale Inferius

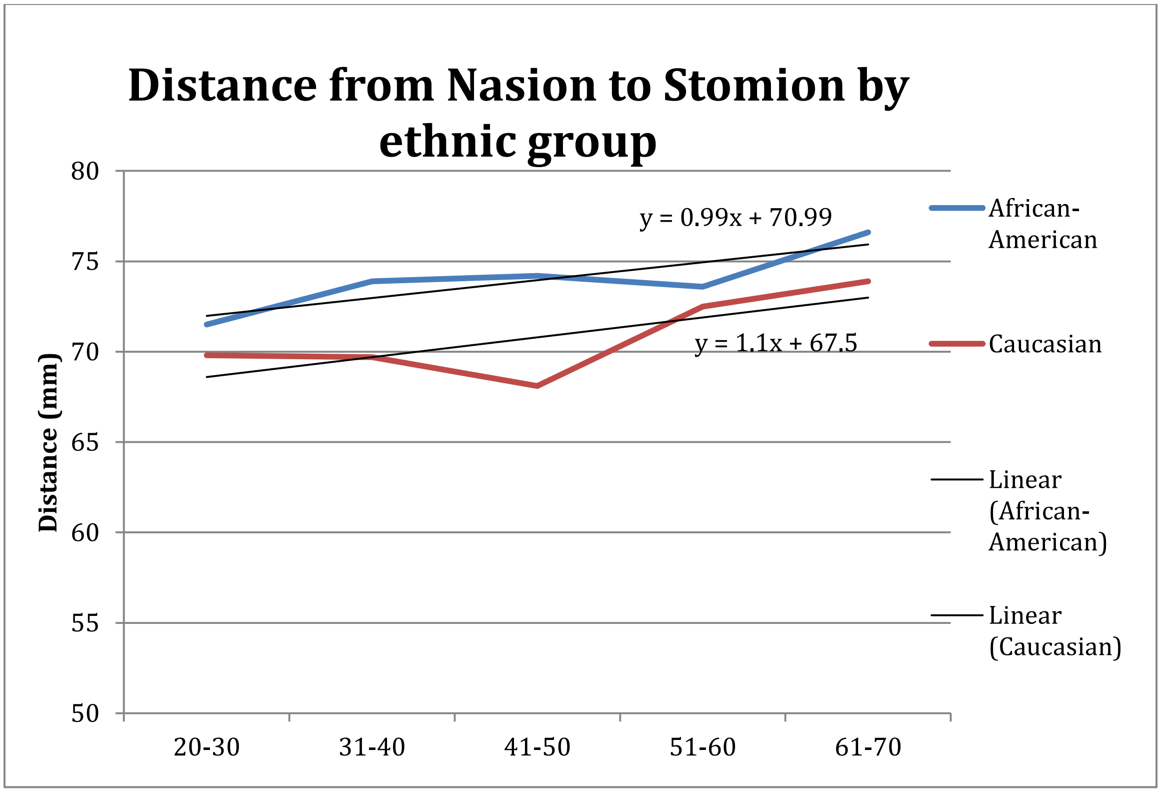

Figure 17: Nasion to Stomion

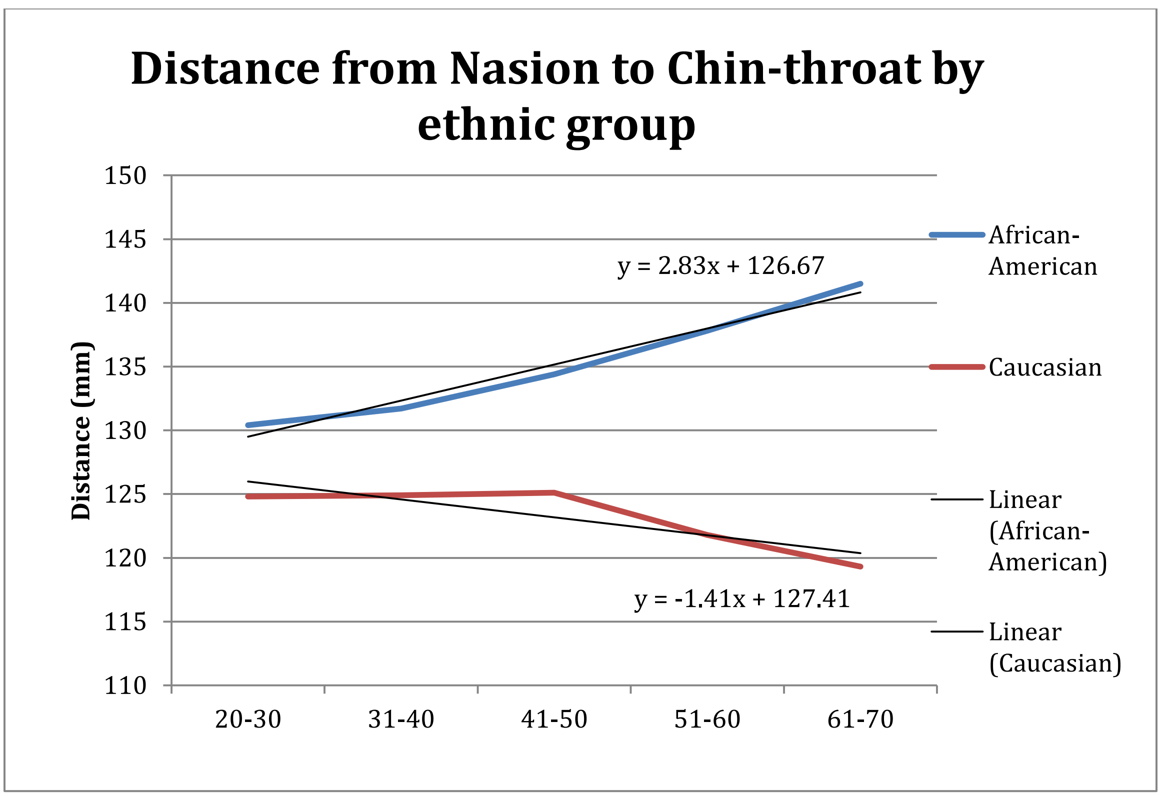

Figure 18: Nasion to Chin-Throat Distance

CHAPTER 4

DISCUSSION

The aim of this study was to examine soft tissue facial aging in the African American female subpopulation and compare this to previously found data on aging of Caucasian females. Previous studies have shown that difference in underlying structural morphology of the face exists between races. In light of these findings, one may predict that aging of the soft tissue of the face may also occur at differing rates. The results of this study show that African American women tend to age significantly in the sixth and seventh decade of life. Aging occurs mostly in the mid-facial area around the eyes, nose and cheekbones, as well as in the chin-throat region. Harris discusses the etiology of premature aging of the African American orbital area in an article on facial rejuvenation. He states that a negative corneal vector relationship, infra-orbital maxillary hypoplasia and thicker corneal tissue leads to a sagging of the soft tissue of the under-eye region[31]. Brissett and Naylor add that underlying differences in the structure of the eyelids, coupled with differing fat distribution and a deficiency in the malar region in African American women leads to advanced aging in this area.[33] These assertions are supported by the present study, as the right and left orbitale points tended to descend in African American women starting in the fourth decade and the right orbitale showed significantly more decent in African Americans than Caucasians. Also, the right and left zygion points in the malar regions sagged significantly over time in a linear fashion for African Americans, whereas Caucasians tended to have little to no change in this area.

In terms of the nasal region, the present study found a lengthening of the distance from nasale to pronasle, subnasale, alare right/left and subalare right/left, indicating that the nasal structures descend with time. This finding agrees with Rohrich et al., who states that over time the nasal tip droops and the nasal length becomes relatively longer.[34] The nasal tip droop occurs earlier and in a more severe fashion in Caucasians. Subnasale and right and left subalare start to lengthen in Caucasians in the fifth decade, whereas African Americans do not see significant changes to these points until the seventh decade of life and the changes are more evident in the Caucasian population. Right and left alare begin to change in African Americans in the 31-40 age group, but the overall change is larger in Caucasians. This study shows that in the nasal area, African Americans tend to age at a slower pace than Caucasians. This may be due to underlying morphological differences between the races.[35] Porter et al. found that African Americans have shorter nasal lengths (nasion-subnasale) than a matched Caucasian population, as well as a more horizontal nasal bridge inclincation.[36] These differences would tend to indicate a lesser degree of nasal tip droop in African American women, which agrees with the results of the present study.

In the lower face, the lips tend to be a focal point and show various changes with aging. Bishara et al. used the records from the Iowa Facial Growth Study (predominately Caucasian population) to examine soft tissue profile changes over time. They noted that the upper and lower lip became more retruded in relation to the Ricketts esthetic line (from pronasale to pogonion) from the age of 15-25. This trend also continued from 25-45 years of age. [4] Therefore, the lips flatten and the loss of soft tissue volume creates a sag in the tissue. This sag is noted in the points of labiale superius and the right and left cristi philtri that descend in both races over time, with more changes seen in the Caucasian population. This result agrees with Brissett and Naylor, who state that the primary etiology for lip thinning and drooping is perioral muscle activity and structural damage caused by ultraviolet (UV) damage. African American women are less prone to damage by UV radiation due to an increase in melanocytes in the skin, so they have a decreased amount of lip thinning and perioral wrinkling.[33] Stomion and labiale inferius show increases in length over time, also indicating lip droop. Behrents et al. found that stomion moves downward vertically and the upper lip lengthens.[37] This was confirmed in this study in both African American and Caucasian women, with similar changes in both races, but African American women tended to have increased values from nasion to stomion and labiale inferius in all age groups. This can be explained by an overall increase in upper and lower lip thickness in African Americans versus Caucasians.[38] Besides the lips, the other area of the lower face that shows significant changes with age in the African American population was the chin-throat point. This area descends linearly over time. Brissett and Naylor attribute soft tissue jowling in African American females to increased submental fat accumulation, as well as a result of the increased weight and thickness of the African American skin. Caucasians also see jowling, but results from a different etiology of skin laxity and underlying skeletal remodeling in the chin region.[33] This phenomenon is noted in the current study with significant changes in the pogonion and gnathion regions for Caucasian subjects, but not for the African American subjects.

The results of this study are subject to several limitations. One potential cause of error would be in the collection of subjects. The recruitment of African American women with a normal body mass was very difficult, especially in the older age groups. The Alabama Health Status Disparities Report in 2010 stated that 37% of African American female adults in the state have a body mass index of over 27.3% (defined as normal) and this percentage is worsening with time.[39] BMI is considered important in an aging study, as excess soft tissue on the face may lead to a more youthful look.

Another limitation of the study is that participants were not screened for a smoking history or asked if they had symptoms of/ had gone through menopause. Morita explains that cigarette smoking increases matrix metalloproteinases in the body, which degrade essential proteins in the skin and leads to premature skin aging.[40] Also, Gold et al. looked at factors associated with the age at which menopause was reached.[41] Although their study found no difference in average age of menopause between Caucasian and African American women, they state this is in contrast to several other studies showing that AA women experience menopause 6-12 months earlier than Caucasians.[42,43] However, they did find that cigarette smoking lead to premature menopause, 1-2 years earlier than their non-smoking counterparts, so the lack of including cigarette smoking as an exclusion criterion could lead to the addition of a confounding variable to the study.

The concept of skin aging and menopause was explored by Reine-Fenning et al., who explain that estrogen receptors on skin cells respond to menopausal changes by altering the collagen content and water content in the skin.[44] These changes cause a decrease in the skins elasticity and strength, leading to an increase in skin sagging. In this manner, menopause does affect the aging of the soft tissues of the face and not accounting for menopausal changes could be a confounding variable as well.

In terms of data collection, another source of error could have arisen from the plotting of the landmarks being done by two different examiners, one for each ethnic group. The Caucasian faces were plotted previously by a pre-doctoral student and the African American faces were plotted by author C.S. Interobserver error between ethnic groups could not be measured, as the two phases of the project were completed at differing time points and the student is constrained by geographic distance from returning for inter-observer measurements to be obtained. However, the student was calibrated with author N.S., as was the author C.S.

In the Caucasian population, the age group 41-50 exhibits smaller linear measurements for most plotted landmarks than all other groups. This can be observed in the tables and as the sharp dip in the graphs for the 41-50 age group in Caucasians. It is assumed that this group was made up of an overall more petite sample of subjects than other groups, resulting in the shorter distances across all the landmarks. This is another limitation of the study, as participants were not matched for height or weight, meaning that a smaller sample may result in one group versus another.

CHAPTER 5

CONCLUSIONS

The phenomenon of aging unites humans as a commonly shared experience across the species. However, the aging of the soft tissues of the face is not uniform across races or individuals. African American females exhibit more aging of the facial soft tissues in the midfacial region than their Caucasian female counterparts, as well as significant aging in the chin-throat area. Facial aging becomes clinically evident in the sixth and seventh decades of life for African American females. While aging seems to occur as a continuous phenomenon in Caucasian females, aging of the soft tissues of the face appears to have a more abrupt onset in this study's African American female group. Facial aging remains an important issue in orthodontics, as treatment planning for adults may vary significantly from that of adolescents and the aging face must be considered to optimize esthetic outcomes for adult patients.

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APPENDIX

INSTITUTIONAL REVIEW BOARD APPROVAL

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM
Institutional Review Board for Human Use

Form 4: IRB Approval Form
Identification and Certification of Research
Projects Involving Human Subjects

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 January 24, 2017. The UAB IRBs are also in compliance with 21 CFR Parts 50 and 56.

Principal Investigator:	SOUCCAR, NADA M
Co-Investigator(s):	SUTHERLAND, CHRISTINA T
Protocol Number:	**X110321003**
Protocol Title:	*Three-Dimensional Age-Related Changes of the Adult Face*

The IRB reviewed and approved the above named project on 2-12-14. 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: 2-12-14

Date IRB Approval Issued: 2-12-14

IRB Approval No Longer Valid On: 2-12-15

Marilyn Doss

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.

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