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A Comparison Of Soft Tissue Topographical Norms For The Local Ethnic People Of Zimbabwe And African American Norms Based On 3Dmd Soft Tissue Photography

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A COMPARISON OF SOFT TISSUE TOPOGRAPHICAL NORMS FOR THE LOCAL ETHNIC PEOPLE OF ZIMBABWE AND AFRICAN AMERICAN NORMS BASED ON 3dMD SOFT TISSUE PHOTOGRAPHY

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ABSTRACT

Introduction: The purpose of this study is to determine the soft tissue topographical norms for the local ethnic people of Zimbabwe and compare them with the African American norms based on 3dMD soft tissue photography. The rationale for the study is to evaluate how the soft tissue drape over the facial skeleton correlates with the different soft tissue analysis widely available today. This study seeks to establish an average base on which clinicians can treat people according to their cultural esthetic perceptions. Previous reported studies only evaluate small numbers of populations and it is well known that different races and ethnic backgrounds have different facial traits.

Materials and Methods: Three-dimensional images were captured using a Stereo-photogrammetric camera system (3dMD ™).

107 Zimbabwean males and 94 Zimbabwean females with no asymmetry or malocclusions and normal BMI of 19 and 22, respectively, were compared to each other and against 50 males and 50 females of African American descent from ages 19-30 from University of Alabama in Birmingham, Alabama, with a normal BMI and same inclusion criteria for the Zimbabwean study. The images captured from both Zimbabwean males and females, were processed by obtaining average shells. Each image was acquired as a facial mesh and oriented along a triangular axis. All facial images were overlaid and

superimposed, using Rapidform 6 software to create a composite facial average for each sex.

Results: The absolute linear measurements showed that the maximum average distance between the Zim-M and Zim-F is 1.24 mm and the minimum distance between the AA-M and AA-F measured at 0.24mm. The signed linear measurement showed a maximum average distance between Zim-F and AA-M of 1.22mm and the least average distance between the Zim-M and AA-M of 0.22mm. The absolute color histograms showed greatest similarity between the Zim-M and AA-M at 58 % and the Zimbabwean females had a 25% and 27% similarity with the AA-F and Zim-M respectively.

The AA-F are more protrusive in the middle forehead area (Trichion), alar base and lateral perioral region and retrusive in the lateral zygomatic region extending down vertically to the gonial and submental regions.

However they displayed more prominence in the glabella, nasion, subnasale and soft tissue pogonion when compared to their African American counterpart.

Conclusion: The 3dMD^{TM} system can be used to map the facial topography of various populations. The Zimbabwean females showed the most variable features with a broader face, prominent forehead and retruded alar base compared to their male counterparts and the Zimbabwean males shows a wider prominent malar/zygomatic region, and prominent lateral supraorbital regions. There was a high similarity of 58% between the Zimbabwean males and the African American males, with the Zimbabwean males showing a more protrusive superciliary arch, and a lateral zygomatic region tapering to the root of the nose.

However they have less prominent mid dorsum, nasal tip and perioral region.

The similarity is 58% at 0.5mm acceptable tolerance, which is the highest in comparison to the others.

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LIST OF ABBREVIATIONS

2-D	Two Dimensional
3-D	Three Dimensional
Zim-M	Zimbabwean Male
Zim-F	Zimbabwean Female
AA-M	African American Male
AA-F	African American Female
CBCT	Cone Beam Computed Tomography
RF6	Rapidform 2006
CAD/CAM	Computer Aided Design/Computer Aided Manufacturing
AFH	Anterior Facial Height
TAFH	Total Anterior Facial Height

CHAPTER 1

INTRODUCTION

What are our objectives in Orthodontics and what are our long-term goals are the questions we always ask as a clinician when evaluating a patient. Every individual has a desire and every orthodontist too, has an end goal on how to treat people. Every individual has their own perception on how they look and how they would like to look.

Over the years we have devised various methods of quantifying how the clinician perceive outcomes.

Individual opinions and “strong egos” were the mainstay of yester years in orthodontics.

Various techniques to image people have evolved.

Development ran concurrently with technology and from anthropological studies to x – rays and finally 3-D imaging was how development occurred.[15]

2-D x-rays imaging is still the mainstay of today’s diagnosis. Even the advent of 3-D imaging has not gained as much ground as it should have.[15]

Zimbabwe, a Southern African country, with a population of 12 million people is home to various tribes, mostly those of Bantu descent.[45]

The Bantu people are made up of various tribes from different regions of geographical Zimbabwe and are made up of five sub clans with different dialects depending on what part of the country they came from.

The Bantu people are known traditionally as the Karanga/Kalanga and presently now known as the Shona. They belonged to an era known as the Monomatapa Empire dating back to the 11th – 16th century, and were known as the house of stones from which the name Zimbabwe is derived from.[45] Their hierarchy is divided into kings, chiefs and sub chiefs.

Orthodontics in Zimbabwe is practiced primarily on parameters based on Caucasian values. [10] This is mostly because there is to date, minimal conclusive data on the cephalometric norm pertaining to both hard and soft tissue for the ethnic population. Various cephalometric studies have been done in some parts of Africa for different ethnicities eg. Ajayi et al in Nigeria and Barter MA et al in South Africa. [1, 5]

African Cephalometric Norms

Connor et al in the mid 80s studied cephalograms of Caucasian and African American people for orthognathic profile preference and found significant variation in various landmarks such as the SNA, ANB, mandibular length and the Wits appraisal. They carried out other soft tissue analysis like teeth display, upper lip length, lower lip length, throat length and lip chin throat angle. [9] Another study by Flynn et al showed that African American had more maxillary skeletal prognathism, increased lower facial height, increased skeletal facial convexity, lower incisor proclination, increased upper and lower lip lengths and increased soft tissue thickness of lips and chin. These subjects also displayed less nasal depth, projection and smaller nasolabial angle in African American people.[17]

Another study done by O'Rilley et al, investigated soft tissue profile change in African Americans after dentoalveolar setback and concluded significant variation in horizontal and vertical lip thickness.[35] Therefore, the quantifiable era of measuring specific values has begun and ethnic differences based on skeletal bases and dentition became more apparent.

The 90s

Soft tissue profile among ethnicities was still an unchartered territory. Many questions about soft tissue profile are now debatable; one interesting study on extraction of first four premolars by Diels et al showed increase in nasolabial angle of 9.1 degrees in males and 7.1 degrees in females. Upper lip procumbency relative to SnPg decreased 1.55mm and 1.7mm and lower lip retraction relative to SnPg was 2.7mm and 2.5mm for males and females respectively.[12] Other studies involving premolar extraction and soft tissue comparisons escalated rapidly. Mesh diagrams based on Moorrees were evaluated and found significant differences in the dentoalveolar complex.[4, 8, 16] Lot of specifics in geometrical analysis between hard and soft tissue has begun and cause effect relationships were more quantifiable.

2000 and Beyond

Anthropometric studies of both males and females continued and only now did ethnic comparisons between various age groups occur.[7, 37-39]

As late as 2007 Beukes et al, studied South African silhouette pictures and evaluated most pleasing and unpleasant profiles and established typical soft tissue values. The most salient feature they noted was upper lip prominence of 5-6mm more than their African American counterparts, however other factors such as angular measurements of nose, lip and chin were in close proximity to those given by Naidoo and Miles.[6]

In 2004, Kau et al evaluated the various types of imaging system and displayed an array of imaging techniques and their reliabilities current at the time.[29] From the morphological study of cherubism to identical twins, the need for ethnic differences arose.[23, 30]

Last but not least and possibly the most relevant to this study is the work of Dandajena and his colleagues who have cephalometrically analysed dentoalveolar relations and anterior facial heights of the Shona people. He found that anterior facial height was higher in men than in women. The older age groups had shorter AFH than the younger group. The AFH of the Shona was lower than that of the African Americans. All AFHs for the men and only TAFHs for the women were significantly shorter for the Shona than the Caucasians.[10]

Another study by the same author involving the study of lateral cephalograms of twelve angular and six linear measurements showed that they had a low FMA with a receding chin. Both the maxilla and mandible SNA and SNB were prognathic and the ANB difference was large. The maxillary incisors were more upright as compared to Caucasian people while measuring the maxillary incisor to NA, while the IMPA were relatively proclined at 105.8 degrees +/- 6.0 degrees and this proclination was considered to be compensatory to the prognathic maxilla.[11]

2-D and 3-D

Evolution is a constant process in all aspects of life, let it be biology or technology, the pursuit for adaptation and improvement is inevitable. The head, with its complex structures comprises of hard and soft tissue that interrelate and interdepend on each other. From inception to death, the formation, integration, maturation and degeneration of tissues is a constant process that never ceases.

Is it possible for Orthodontists to "steal" a fragment of time during that process where the manipulation of structures relevant for the benefit of function and esthetics to the patients they treat. The professions learning curve till date is still cemented in 2-D x-rays evaluation and diagnosis.[29]

From the advent of photographs, x-rays, and study models, all structures are analyzed separately and not together, therefore we cannot put it all into perspective. The dental models only look at the teeth, the photos only look at soft tissue and the x-rays look at the skeleton in 2-D.[24]

To add to the diagnosis complexity, layperson and the treating orthodontist have different views in what goals they desire and therefore arriving towards a common treatment outcome is not as easy as it may seem.

Chan et al studies the perceptions of white orthodontists when treating Chinese-Asian patients and preferred the Class I, straight profile to the traditional norm of the slightly bi maxillary protrusive profile.

In another study by Cochrane, parents, dentists and orthodontists were asked to evaluated 2-D photos and found that the trained specialists focused on mid and lower thirds of the face, while the layperson focused on the entire face. Profile preferences too were apparent between the two groups.

Since the arrival of Cone Beam Computed Tomography (CBCT), the z – axis that represents the third dimension, has changed the way we look at hard tissues. It provides a wealth of information such as exact tooth position, supernumerary teeth, thickness of bone, morphology of hard structures and better tempromandibular joint visualization.

It is now used for other aspects of dentistry such as implant placements, osteotomies, surgical planning, periodontal evaluation and airway patency.[22]

3-D Facial Scanning

This is a process where by the facial morphology is captured in all three dimensions. The methods should me non-invasive, non-ionizing and fast.[32]

Direct Contact Devices

These devices are the oldest facial scanning units. They collect data by contacting the patients face at specific points. A reference framework is constructed by marking fiducial points of known coordinates and then an electronic probe is used to landmark the rest of the surface.[15]

Laser Scanning

Lasers have no color information; they are taken at different angles at separate moments and digitally fused together. The projection of the laser beam is fan shaped and more than 300 000 points on the surface of face are measured and on projection will distort and reflect. A charged couple device camera then captures this reflection with mirrors in the image that allow the reflected scan to be viewed from two opposing directions.[28] Difference between triangulating the laser beam and the scanned surface will detect objects length, width, and depth. [34]

Stereo-photogrammetry

This is a camera system where photographs are taken from two different positions and convert it into a three dimensional image. Their configuration is a two or four cameras configured as a stereo pair which enables it to obtain three-dimensional surface topography. [26] Mathematical algorithms, a geometric calculation performs a triangulation routine with the known positions of the camera sensors. The images are displayed as a polygonal mesh, a point cloud, or computer aided design/computer assisted manufacturing (CAD/CAM). The advantage of such a system is rapid image capture, generation, display, and accurate reproducibility of surface landmarks to within 0.5mm. [18] The disadvantages however are that commercially available software must be validated and is needed to convert the files and images with high accuracy. Voids in the images around the nasal and para nasal areas are created by shadows casted by opposing camera flashes.[2]

Structured Light Technique

This system unlike stereo photogrammetry uses only one capture to create an image. A projected " structured" light is cast on the image being recorded and the feedback is a distorted light form caused by the topography of the object. The camera is placed at a known distance that will capture the reflected, distorted pattern of light and that information will be translated into three-dimensional coordinates.[31]

3dMDfaceTM System

This is a newer system currently available on the market that combines both, stereo photogrammetry and structured light into one system called the 3dMD faceTM system.[21] It uses two sets of cameras, each set consisting of two infrared and one color camera to capture the 3-D image. A structured pattern of light is projected on the patients face and an image is taken simultaneously from different angulations. The image is captured spontaneously and the requirement to "stitch" the image after post data capture is no longer required.

The extent of the image is from ear to ear and from chin to hairline, and has a capture speed of 1.5milliseconds. This capture speed is a benefit when dealing with young children. The manufacturer states the accuracy of 0.5mm (Root Mean Square) and a clinical accuracy of 1.5% of the total observed variance.[2]

The system is portable, easy to set up, accurate and has a fast capture time. Aldridge et al tested the repeatability of a group of images obtained from this system and found it to be very accurate, with a high level of precision.[2]

A newer meta-analysis linking 3dMD quantitative analysis and a genome wide study shows evidence linking genetics to facial morphology. Little evidence exists on variations in specific regions of the genome relates to the kinds of distinguished facial characteristics that give us our unique identities. Genetic associations involve measurements of eyes, nose and facial breath. These areas represent a specific trait pattern and therefore are linked to specific loci on genes. This will better help geneticists predict craniofacial anomalies and improve ability to create forensic facial reconstruction from DNA.[44]

Soft Tissue Hard Tissue Paradigm

The specialty of Orthodontics has been based on the Angle paradigm which involved treating the hard tisues only, getting the teeth into perfect occlusion and allowing soft tissue to folllow. The soft and hard tissue are an intricate paired phenomenon, where by one influences the other in an ever constant dynamic interaction. [3] Teeth usually occupy a neutral zone between muscular intra oral tissues such as the tongue and extra oral soft tissue like the muscles of facial expression and their whole related complex. [40]Treating only the hard tissues over the years created dental relapse due to displacement from the neutral desired positions. This creates a plathora of variations.

In recent years with the advent of better imaging techniques, the influence of soft tissue can be better studied. Proffit stated that when deciding wether to extract or not, in crowded arches or in anterior posterior discrepancies it is important to consider lip support. This has shed light on soft tissue profile changes in extraction and non extraction cases and how this invariably influence each other. This variation is vast and represents different traits in various populations. [41]

Support of the upper and lower lips has been shown as the patient ages due to lip thickness decreasing and lengthening, possibly due to constant pull of gravity and increased in tissue laxity. It is important to consider lip support during extraction vs non-extraction decision.[8]

The trempromandibular joint plays an important role in soft tissue support. A muscular sling made up of the masseter and medial pterygoid muscles supports the mandible and plays a critical role in the position of the mandibular condyles in the glenoid fossa.[36]

Tissue thickness around the roots of the teeth can provide different responses to tooth movement. Teeth covered by thin friable gingival tissue and thin attached gingiva may be more at risk for gingival recession if the tooth has moved facially out of its alveolar bone housing, and in the presence of active periodontal disease, orthodontic forces can exacerbate the destruction of supporting tissue. Gingival recession has been often reported on the buccal surfaces of maxillary molars and premolars in patients treated with maxillary palatal expander. [19]

Specific Aims Of The Study

To determine the average morphology of the Zimbabwean people both male and female in a specific age group and compare facial morphological differences of the Zimbabwean people to that of African American norms in Birmingham, Alabama of a similar age.

CHAPTER 2

MATERIALS AND METHODS

Subjects were selected from the capital city Harare, Zimbabwe. Both sample sizes were randomly selected from a specific age group from the surrounding metropolitan area.

The group comprised of 107 males and 94 females. A questionnaire was handed out to determine demographical origin and other inclusion criteria that include:

1- Subjects between the age of 18-30 years
2- Ethnicity of Shona descent
3- Subjects had no adverse skeletal deviations
4- Subjects had no craniofacial anomalies
5- Normal BMI measured from height and weight.
6- No previous orthognathic surgery
7- No history of orthodontics

Imaging System

The 3dMDfaceTM system used for this comprised of two Infrared cameras, one color camera which casts a random light pattern on the object. The picture capture is from different angles to represent the image in three dimensions. Capture time is 1.5 msec with an accuracy of 1.5%[33]

Image Acquisition

Natural head position was used in all subjects because it is the most attainable and reproducible. The subjects sat on an adjustable chair and were asked to look into a mirror set in front of them.

Their eyes were levelled, by looking into the mirror and stool adjusted according to their heights as required. They were asked to swallow and keep jaws relaxed just before image capture. Each acquisition took 1.5 milliseconds. The image was reviewed before the patient was dismissed to assure no image distortion.

Processing Of Facial Shells

All images imported to Rapidform software 2006, INUS Technology, Seoul, Korea (RF6) for analysis. Poorly defined areas such as the hair, ears, neck and shoulders are cropped out and all other surface defects are smoothened out. One facial shell for each individual is created.[27]

Average Face Construction

Once the shells were formed, they were aligned and created to the best-fit algorithm to form one average shell, one for the females the other for males. The steps required to produce and average are summarised as follows:

1. The images were aligned to form the principal axis of rotation, also known as the centre of mass.
2. Manual alignment can also be used to improve the position.

3. A built in algorithm in RF6 calculated the best fit for the shells for accurate registration.
4. The coordinates of the images were averaged based on a facial template.
5. The output of the average algorithm gives a point cloud reading, which is then triangulated to obtain an average face.
6. Filling in or snubbing any mesh defects improves the average faces.
7. A colour texture is then applied. Shells with one positive and one negative deviation were created.

Parameters Measured

Two average facial shells were generated: Zimbabwean male (Zim-M), Zimbabwean female (Zim-F). These shells were superimposed on each other, males first as a base template then females as an overlay.

A specialized technique to compare morphological differences was used. This process comprised of manually aligning five points of the facial scans, two points on outer canthus of both eyes and two points on the inner canthus of both eyes and one point on the tip of the nose. The RF6 software then determines the best fit of the two shells.

The parameters used to study these results were:

1. Linear measurements in millimeter, are both Absolute and Signed, which measure the greatest difference between and within the shells respectively.
2. Color histograms as a percentage, which show similarities, positives and negatives.
3. Surface areas and shapes, which shows range of distribution.

Linear Measurements

The differences are measured by a linear measurement at any given point of the facial topography. The linear difference is the discrepancy between the two shells. This value can also be used to quantify the deviation. This linear average also provides a percent similarity of the face, which gives the shell perception difference.

Color Histograms

The two shells are compared with each other with one being the base and the other a superimposition. A positive difference is noted if the superimposed shell is more prominent than the base and a negative difference is noted if the superimposed shell is more deficient than the base. The differences are identified by different color depictions, black indicating similarity between the shells, red indicating a positive change (prominence) and blue indicating a negative change (deficient). This allows us to distinguish and analyse surface topography and its differences.

Surface Area and Shapes

This is automatically generated by the RF6 software with a tolerance level of 0.50mm applied to the paired surface shells. This value is derived from previous work that shows that 90% of created composite scans are within the 0.85mm error. Therefore the chosen tolerance levels of an average correspond to 0.50mm. Any variations within 0.50mm were considered to be similar surfaces, while surface areas outside this tolerance showed as surface shapes and color deviations.

CHAPTER 3

RESULTS

The final sample included two hundred and one people, 107 men and 94 women. Average faces were constructed for each of the groups and compared to each other and to that of African Americans in Birmingham, Alabama (50 men and 50 women). Their mean age was 28 for males and 27 for females with a BMI of 19 and 22 respectively.

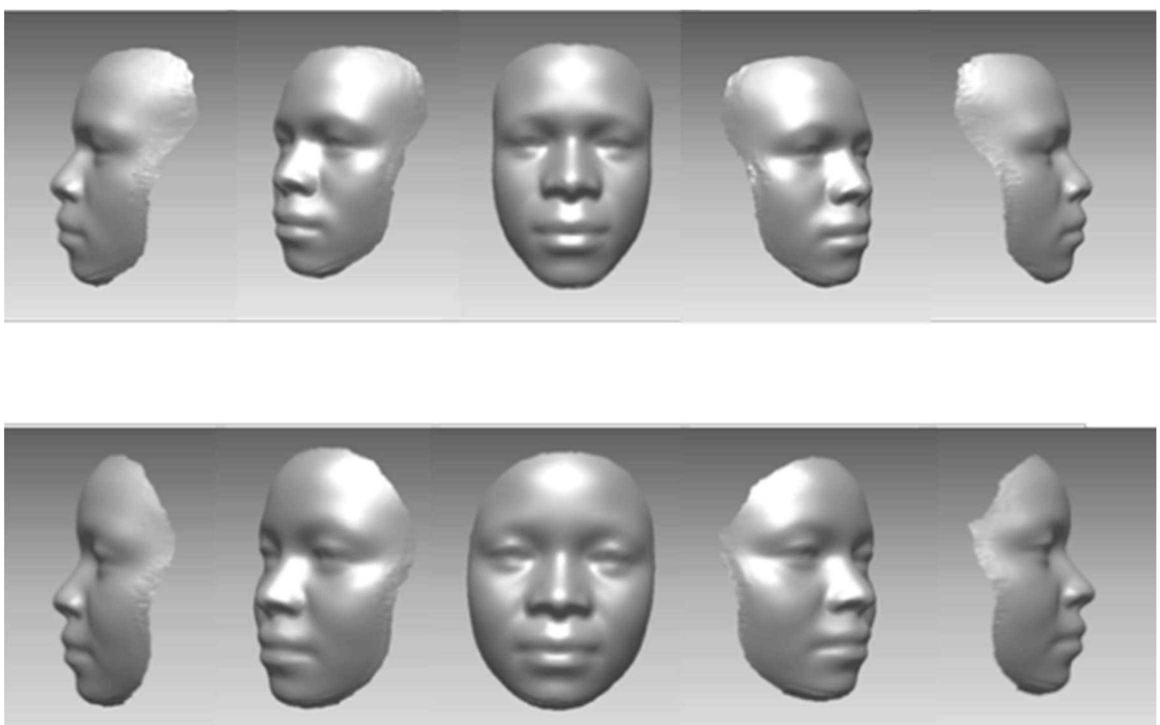


Figure 1: Average facial constructions for the Zimbabwean males (row 1) and the Zimbabwean females (row 2)

Figure 2: Average African American males (row 1) and African American females (row 2).

Measurements

The two shells are superimposed over each other using one as the base shell and the other as the superimposed. The results of the study are as follows.

Linear Measurements

Differences in the average absolute linear measurements between the surface shells were noted in the two groups. The absolute linear measurement in gender differences ranged from 0.42mm (AA-M vs AA-F) to 1.24 mm (Zim-F vs Zim-M) as shown in Table 1.

Further differences between Zimbabwean and African American are listed below. The maximum distance of 5.09mm is seen in (Zim-F vs Zim-M), while the minimum of 2.02mm is seen in (Zim-M vs AA-M).

Table 1:

Absolute linear measurements indicating differences between facial shells

	Avg. Distance (mm)	Std. Dev. (mm)	Max. Distance (mm)
Zim-M vs Zim-F	1.24	1.20	5.09
AA-F vs Zim -F	1.16	0.87	4.21
Zim-F vs AA-M	1.22	0.96	4.47
Zim-M vs AA-M	0.51	0.41	2.02
AA-F vs Zim-M	1.04	0.92	5.01
AA-F vs AA-M	0.42	0.35	2.99

Table 2:

Signed color map measurement indicating differences in facial shells

	Avg. Distance (mm)	Std. Dev. (mm)	% Similarity
Zim-M vs Zim-F	0.35	1.62	27.08
AA-F vs Zim-F	0.39	1.40	25.79
Zim-F vs AA-M	0.55	1.45	28.79
Zim-M vs AA-M	0.02	0.66	58.75
AA-F vs Zim-M	0.04	1.39	36.19
AA-F vs AA-M	-0.07	0.54	57.57

Color Histograms

The differences in color histograms between Zimbabwean males and females are shown in table 2. The % similarity is 27.08%. The greatest amount of similarity is seen between the Zim-M vs. AA-M at 58.75%, which is quite significant. The AA-M vs AA-F too had a high similarity of 57.57%.

The Zim-F sample seems to be the most dissimilar group when compared to their male counterparts and also to that of the AA-M and AA-F. The results in the signed color histograms show the similarities between the same sex individual of different ethnicities but very dissimilar among their own ethnic groups.

Surface Area /Shapes

The differences seen in the surface area and the shapes of the facial shells are seen in fig 3and 4.

Zim-M vs Zim F

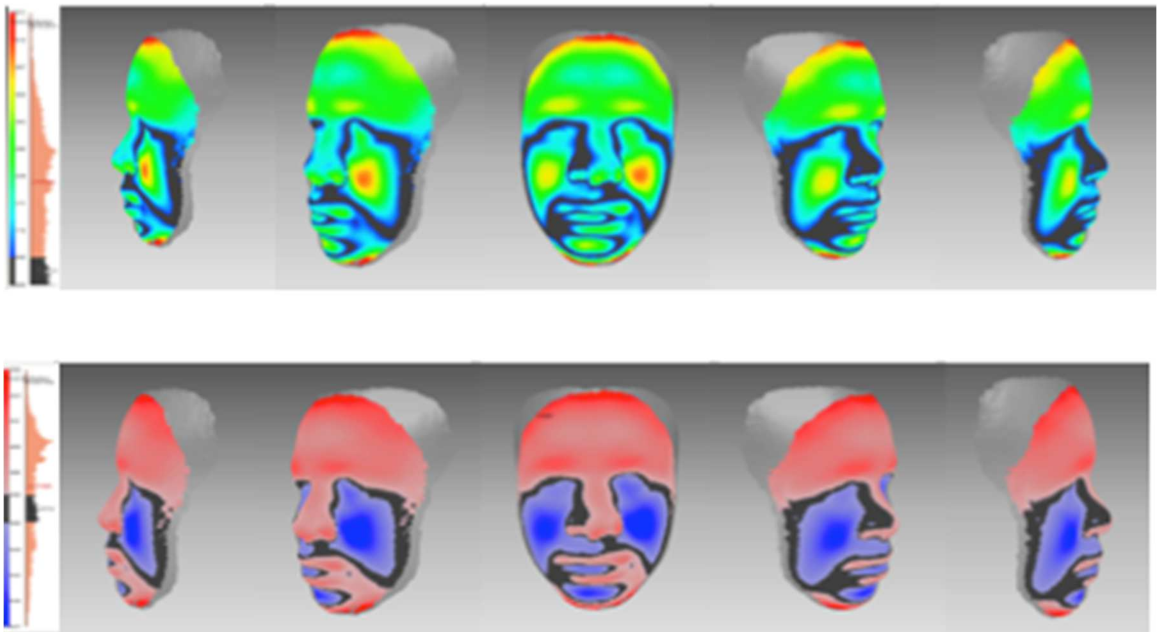
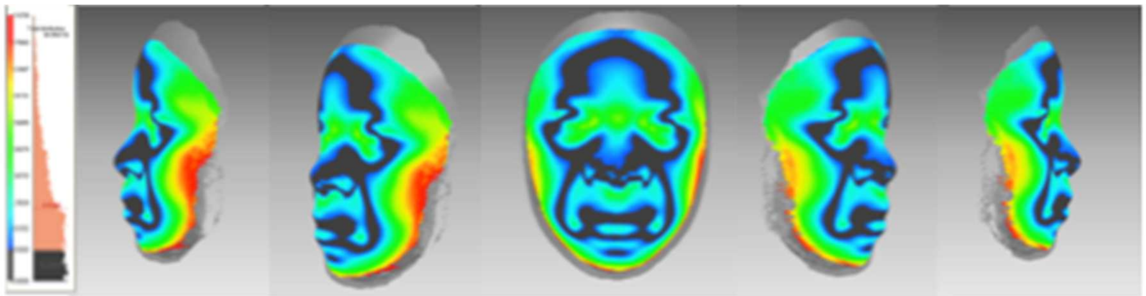


Figure 3: Absolute and Signed histograms of Zim-M vs Zim-F

AA-F vs Zim- F



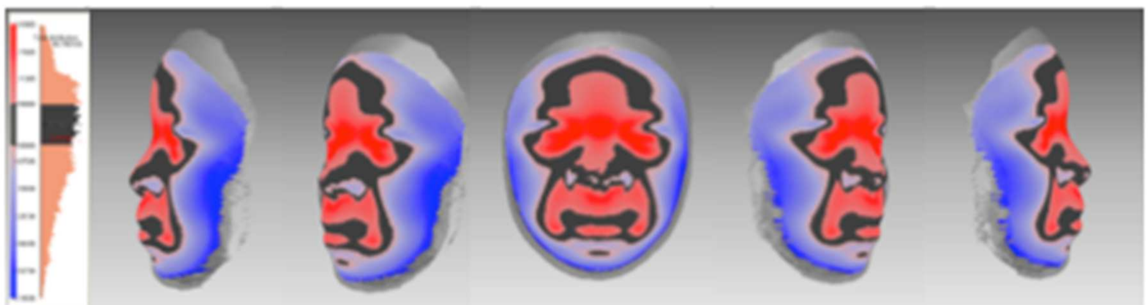
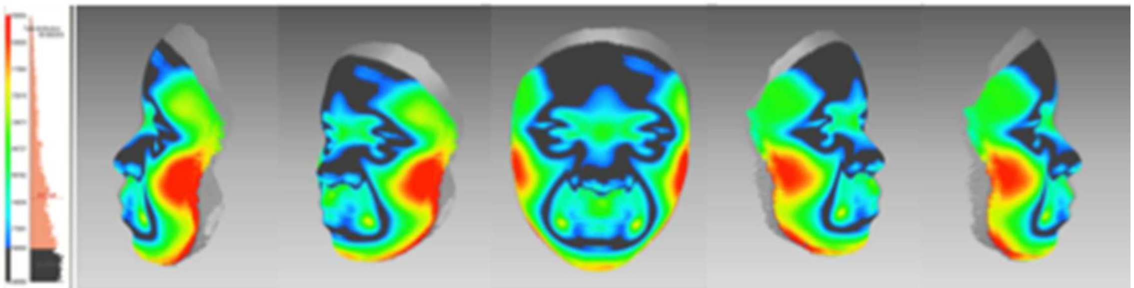


Figure 4: Absolute and signed histogram of AA-F vs Zim-F

Zim-F vs AA-M



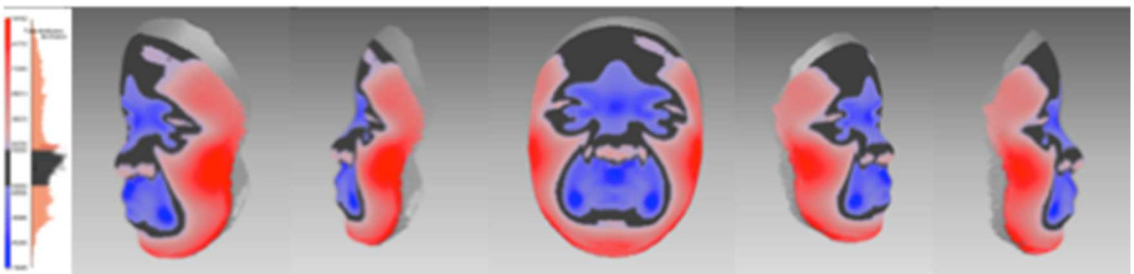


Figure 5: Absolute and signed histogram of Zim-F vs AA-M

Zim-M vs AA- M

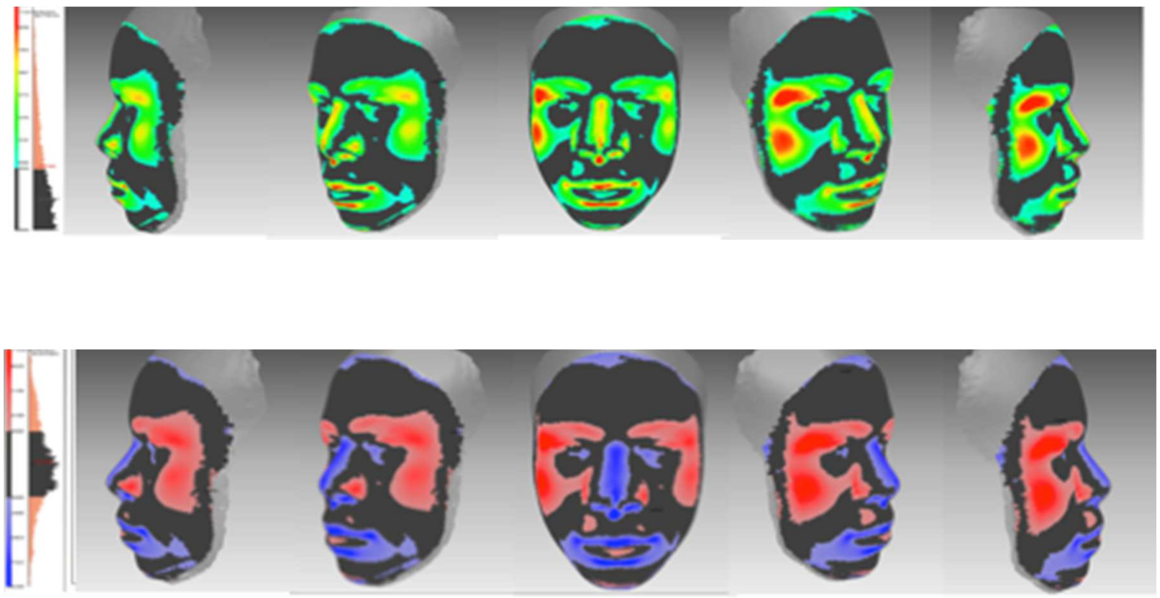


Figure 6: Absolute and Color histogram of Zim-M vs AA-M

AA-F vs Zim-M

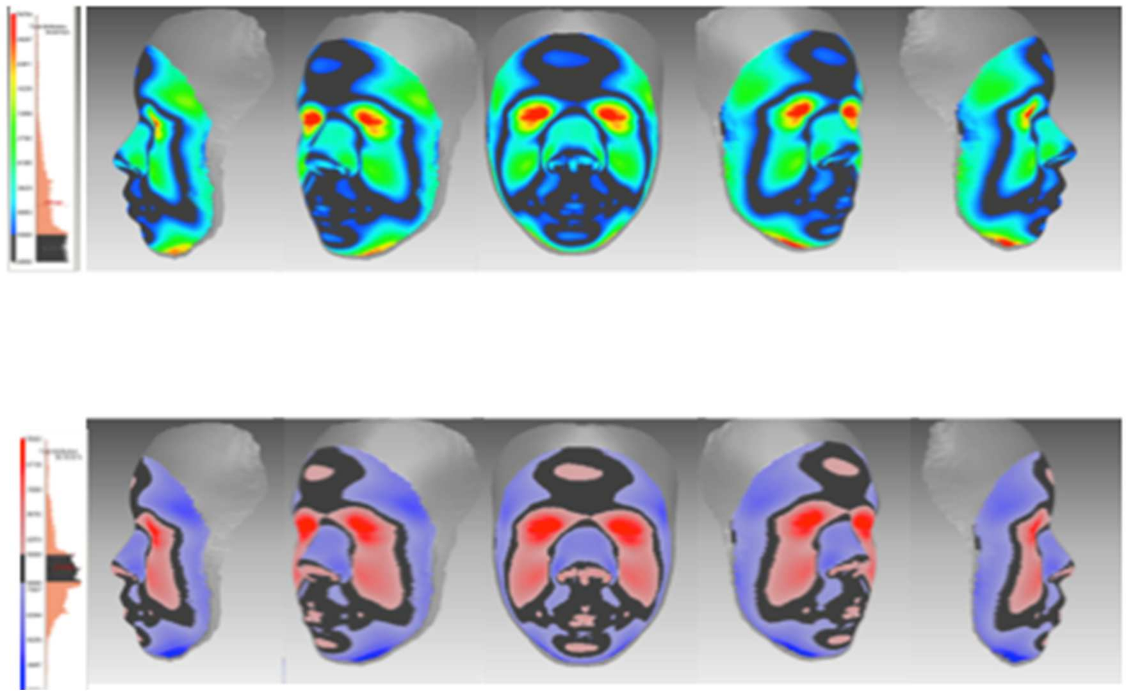


Figure 7: Absolute and Color histogram of AA-F vs Zim-M

AA-F vs AA-M

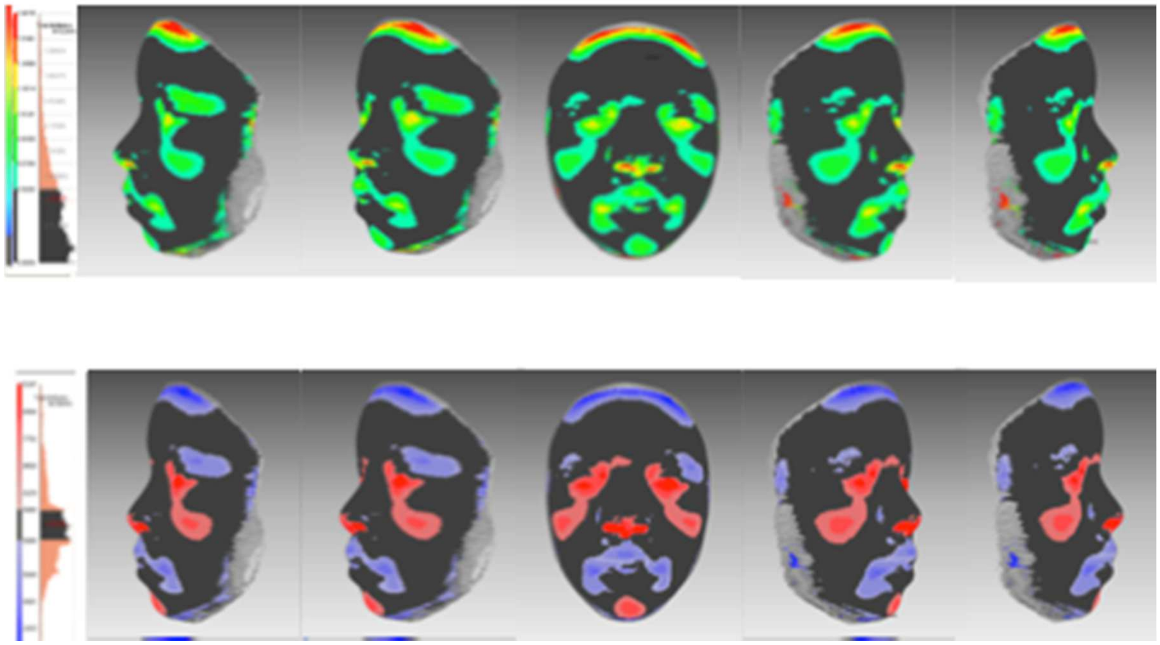


Figure 8: Absolute and Color histogram of AA-F vs AA-M

CHAPTER 4

DISCUSSION

Technological advances have occurred slowly and steadily. For most of this century diagnosis was based on two-dimensional analysis of which more that twelve different ones are utilized, each analysis pertaining to their own clinical significance and relevance. An unending quest to correlate the second and third dimension has taken its toll on many clinicians.[42]

With the world racing ahead to conquer imaging frontiers, the advent of cone beam computed technology (CBCT) was born. A whole new dimension we always new existed enlightened us with accurate visualisation of clinical deficiencies. Unfortunately as the world goes ahead, the continent of Southern Africa, particularly Zimbabwe trails ever so slowly.[25]

Very few studies on two-dimensional analysis have been done on native southern African people, let alone three-dimensional. Isiekwe et al, studied the nose prominence relative to other structures, of an adult Nigerian population, using the Holdaway analysis.[20]

A few photogrammetric studies of North African countries, such as Senegalese students versus Moroccans students where by linear measurements were taken to quantify their differences. [13] Another Sudanese study used a hand laser scanner in 653 subjects and analysed 14 landmarks on the facial soft tissue. [43]

Soft tissue cephalometric studies on Nigerians, Ghanaians, and Sudanese teenagers were done to determine soft tissue pattern and compared to that of Caucasian counterparts. Significant statistical difference was apparent.[14] Only one soft tissue profile study was done in South Africa to establish a profile index for bimaxillary protrusion and soft tissue preference.[6]

Zimbabwean Male and Female Morphology

When looking at the color histograms, the Zimbabwean males show a more protrusive forehead, supraorbital and nasal bridge area while being retrusive in the infraorbital and lateral alar region.

They also showed accentuated perioral region. The similarities between the two sexes are the lateral parts of the nose, subnasal area superior portion of the lip extending down to the corner of the mouth towards the parasymphysis area.

Comparison Between Population Sub Groups

When comparing histograms of the same sexes but of different population groups the similarities for the males were considerably higher than the females. The similarities were in the inner canthus of the eyes, lateral nasal region, sub mental and lower borders of the chin. The noticeable difference between them were nasal and perioral areas which showed a more retrusive region while the malar/zygomatic and lateral periorbital ridges are more prominent. The females between the two sub groups were more dissimilar with the forehead, inner canthus of the eyes, nasal bridge, upper and lower lips being more prominent, while the lateral aspects of the face that is the malar region extending down to the mandible seem more retrusive.

Clinical Implications

It is apparent than all along we have been diagnosing and categorizing various ethnic groups into a general pool of Caucasian norms. The current trend of treating facial profile first and dentition to follow has taken great precedence. Understanding soft tissue norms first and then comparing them to other average shells gives us a perspective on variations. This allows us to plan incisor positions according to average profiles for that age group and it also gives us a basis to form data on which we can build a foundation to understand trends among ethnicities.

However all observations made from this thesis are taken from facial averages which are superimposed on each other and will not apply to every patient, it is just a diving platform where a basis to treatment can be applied.

Limitation Of The Study

This study provides qualitative information on the facial morphology of Zimbabwean males and females from a very specific group in and around the campus of the University of Zimbabwe. It may not represent the entire region since the sample size was only obtained from the capital city.

This allows clinicians to visualize the variations seen between these population groups. The image shell is only a fragment of time between 18-30 years old. Further studies like a quantitative analysis using the 3dMD Vultus™ (Atlanta, GA) can be used to further quantify variations in anatomical landmarks.

Muscle tonicity, aging, and tissue drape, at various age groups can be scope for further research.

CHAPTER 5

CONCLUSION

- 3dMD^{TM} imaging system is fast, reliable, non-invasive, and non-ionizing.
- The Zimbabwean males have a prominent zygomatic, lateral supraorbital and infraorbital regions. Bridge of the nose and perioral area around the lips were also retrusive.
- The dimorphism between the two sexes are that Zimbabwean males show a more protrusive forehead, supraorbital and nasal bridge area while being retrusive in the infraorbital and lateral alar region. They also showed accentuated perioral region
- When compared to African American males, the Zimbabwean males show wider supraorbital regions but smaller more retruded perioral regions
- When compared to African American females the Zimbabwean females show a subtler malar region with less prominent lips.
- When compared to Zimbabwean females. The African American females are more protrusive in the middle forehead area, alar base and lateral perioral region. Retrusive in the lateral zygomatic region, gonial, and submental area.

REFERENCES

1 E. O. Ajayi, 'Dental Aesthetic Self-Perception and Desire for Orthodontic Treatment among School Children in Benin City, Nigeria', *Nig Q J Hosp Med,* 21 (2011), 45-9.

2 K. Aldridge, S. A. Boyadjiev, G. T. Capone, V. B. DeLeon, and J. T. Richtsmeier, 'Precision and Error of Three-Dimensional Phenotypic Measures Acquired from 3dmd Photogrammetric Images', *Am J Med Genet A,* 138A (2005), 247-53.

3 G. W. Arnett, J. S. Jelic, J. Kim, D. R. Cummings, A. Beress, C. M. Worley, Jr., B. Chung, and R. Bergman, 'Soft Tissue Cephalometric Analysis: Diagnosis and Treatment Planning of Dentofacial Deformity', *Am J Orthod Dentofacial Orthop,* 116 (1999), 239-53.

4 K. L. Bailey, and R. W. Taylor, 'Mesh Diagram Cephalometric Norms for Americans of African Descent', *Am J Orthod Dentofacial Orthop,* 114 (1998), 218-23.

5 M. A. Barter, W. G. Evans, G. L. Smit, and P. J. Becker, 'Cephalometric Analysis of a Sotho-Tswana Group', *J Dent Assoc S Afr,* 50 (1995), 539-44.

6 S. Beukes, S. M. Dawjee, and P. Hlongwa, 'Soft Tissue Profile Analysis in a Sample of South African Blacks with Bimaxillary Protrusion', *SADJ,* 62 (2007), 206, 08-10, 12.

7 R. A. Brock, 2nd, R. W. Taylor, P. H. Buschang, and R. G. Behrents, 'Ethnic Differences in Upper Lip Response to Incisor Retraction', *Am J Orthod Dentofacial Orthop,* 127 (2005), 683-91; quiz 755.

8 M. J. Caplan, and P. K. Shivapuja, 'The Effect of Premolar Extractions on the Soft-Tissue Profile in Adult African American Females', *Angle Orthod,* 67 (1997), 129-36.

9 A. M. Connor, and F. Moshiri, 'Orthognathic Surgery Norms for American Black Patients', *Am J Orthod,* 87 (1985), 119-34.

10 T. C. Dandajena, K. W. Chung, and R. S. Nanda, 'Assessment of Anterior Face Height in a Native African Sample', *Am J Orthod Dentofacial Orthop,* 130 (2006), 196-201.

11 T. C. Dandajena, and R. S. Nanda, 'Bialveolar Protrusion in a Zimbabwean Sample', *Am J Orthod Dentofacial Orthop,* 123 (2003), 133-7.

12 R. M. Diels, V. Kalra, N. DeLoach, Jr., M. Powers, and S. S. Nelson, 'Changes in Soft Tissue Profile of African-Americans Following Extraction Treatment', *Angle Orthod,* 65 (1995), 285-92.

13 J. S. Diouf, P. I. Ngom, M. S. Fadiga, A. Badiane, K. Diop-Ba, M. Ndiaye, and F. Diagne, '[Sagittal Photogrammetric Evaluation of the Soft Tissue Profile

between Two Different Racial Groups: A Comparative Study]', *Odontostomatol Trop,* 38 (2015), 5-14.

14 A. D. Fadeju, O. D. Otuyemi, P. I. Ngom, and M. Newman-Nartey, 'A Study of Cephalometric Soft Tissue Profile among Adolescents from the Three West African Countries of Nigeria, Ghana and Senegal', *J Orthod,* 40 (2013), 53-61.

15 L. G. Farkas, M. J. Katic, C. R. Forrest, K. W. Alt, I. Bagic, G. Baltadjiev, E. Cunha, M. Cvicelova, S. Davies, I. Erasmus, R. Gillett-Netting, K. Hajnis, A. Kemkes-Grottenthaler, I. Khomyakova, A. Kumi, J. S. Kgamphe, N. Kayo-daigo, T. Le, A. Malinowski, M. Negasheva, S. Manolis, M. Ogeturk, R. Parvizrad, F. Rosing, P. Sahu, C. Sforza, S. Sivkov, N. Sultanova, T. Tomazo-Ravnik, G. Toth, A. Uzun, and E. Yahia, 'International Anthropometric Study of Facial Morphology in Various Ethnic Groups/Races', *J Craniofac Surg,* 16 (2005), 615-46.

16 M. M. Faustini, C. Hale, and G. J. Cisneros, 'Mesh Diagram Analysis: Developing a Norm for African Americans', *Angle Orthod,* 67 (1997), 121-8.

17 T. R. Flynn, R. I. Ambrogio, and S. J. Zeichner, 'Cephalometric Norms for Orthognathic Surgery in Black American Adults', *J Oral Maxillofac Surg,* 47 (1989), 30-9.

18 P. Hammond, T. J. Hutton, J. E. Allanson, L. E. Campbell, R. C. Hennekam, S. Holden, M. A. Patton, A. Shaw, I. K. Temple, M. Trotter, K. C. Murphy, and R. M. Winter, '3d Analysis of Facial Morphology', *Am J Med Genet A,* 126A (2004), 339-48.

19 R. J. Herberger, 'Stability of Mandibular Intercuspid Width after Long Periods of Retention', *Angle Orthod,* 51 (1981), 78-83.

20 G. I. Isiekwe, O. O. daCosta, I. L. Utomi, and O. O. Sanu, 'Holdaway's Analysis of the Nose Prominence of an Adult Nigerian Population', *Niger J Clin Pract,* 18 (2015), 548-52.

21 C. H. Kau, A. J. Cronin, and S. Richmond, 'A Three-Dimensional Evaluation of Postoperative Swelling Following Orthognathic Surgery at 6 Months', *Plast Reconstr Surg,* 119 (2007), 2192-9.

22 C. H. Kau, J. D. English, M. G. Muller-Delgardo, H. Hamid, R. K. Ellis, and S. Winklemann, 'Retrospective Cone-Beam Computed Tomography Evaluation of Temporary Anchorage Devices', *Am J Orthod Dentofacial Orthop,* 137 (2010), 166 e1-5; discussion 66-7.

23 C. H. Kau, S. G. Kamel, J. Wilson, and M. E. Wong, 'New Method for Analysis of Facial Growth in a Pediatric Reconstructed Mandible', *Am J Orthod Dentofacial Orthop,* 139 (2011), e285-90.

24 C. H. Kau, J. L. Li, Q. Li, and N. Abou Kheir, 'Update on Cone Beam Technology and Orthodontic Analysis', *Dent Clin North Am,* 58 (2014), 653-69.

25 C. H. Kau, J. Littlefield, N. Rainy, J. T. Nguyen, and B. Creed, 'Evaluation of Cbct Digital Models and Traditional Models Using the Little's Index', *Angle Orthod,* 80 (2010), 435-9.

26 C. H. Kau, and S. Richmond, 'Three-Dimensional Analysis of Facial Morphology Surface Changes in Untreated Children from 12 to 14 Years of Age', *Am J Orthod Dentofacial Orthop,* 134 (2008), 751-60.

27 C. H. Kau, S. Richmond, C. Savio, and C. Mallorie, 'Measuring Adult Facial Morphology in Three Dimensions', *Angle Orthod,* 76 (2006), 773-8.

28 C. H. Kau, S. Richmond, A. I. Zhurov, J. Knox, I. Chestnutt, F. Hartles, and R. Playle, 'Reliability of Measuring Facial Morphology with a 3-Dimensional Laser Scanning System', *Am J Orthod Dentofacial Orthop,* 128 (2005), 424-30.
29 C. H. Kau, S. Richmond, A. Zhurov, M. Ovsenik, W. Tawfik, P. Borbely, and J. D. English, 'Use of 3-Dimensional Surface Acquisition to Study Facial Morphology in 5 Populations', *Am J Orthod Dentofacial Orthop,* 137 (2010), S56 e1-9; discussion S56-7.
30 C. H. Kau, N. M. Souccar, J. D. English, S. G. Kamel, and M. E. Wong, 'The Surgical and Orthodontic Management of Cherubism in a Growing Child', *J Craniomaxillofac Surg,* 40 (2012), 229-33.
31 C. H. Kau, A. Zhurov, R. Bibb, L. Hunter, and S. Richmond, 'The Investigation of the Changing Facial Appearance of Identical Twins Employing a Three-Dimensional Laser Imaging System', *Orthod Craniofac Res,* 8 (2005), 85-90.
32 C. H. Kau, A. Zhurov, S. Richmond, A. Cronin, C. Savio, and C. Mallorie, 'Facial Templates: A New Perspective in Three Dimensions', *Orthod Craniofac Res,* 9 (2006), 10-7.
33 C. H. Kau, A. Zhurov, R. Scheer, S. Bouwman, and S. Richmond, 'The Feasibility of Measuring Three-Dimensional Facial Morphology in Children', *Orthod Craniofac Res,* 7 (2004), 198-204.
34 J. P. Moss, A. D. Linney, and M. N. Lowey, 'The Use of Three-Dimensional Techniques in Facial Esthetics', *Semin Orthod,* 1 (1995), 94-104.
35 M. T. O'Reilly, 'Integumental Profile Changes after Surgical Orthodontic Correction of Bimaxillary Dentoalveolar Protrusion in Black Patients', *Am J Orthod Dentofacial Orthop,* 96 (1989), 242-8.
36 J. P. Okeson, 'Evolution of Occlusion and Temporomandibular Disorder in Orthodontics: Past, Present, and Future', *Am J Orthod Dentofacial Orthop,* 147 (2015), S216-23.
37 J. P. Porter, 'The Average African American Male Face: An Anthropometric Analysis', *Arch Facial Plast Surg,* 6 (2004), 78-81.
38 J. P. Porter, and K. L. Olson, 'Analysis of the African American Female Nose', *Plast Reconstr Surg,* 111 (2003), 620-6; discussion 27-8.
39 ———, 'Anthropometric Facial Analysis of the African American Woman', *Arch Facial Plast Surg,* 3 (2001), 191-7.
40 W. R. Proffit, 'Muscle Pressures and Tooth Position: North American Whites and Australian Aborigines', *Angle Orthod,* 45 (1975), 1-11.
41 ———, 'Muscle Pressures and Tooth Position. A Review of Current Research', *Aust Orthod J,* 3 (1973), 104-08.
42 ———, 'The Soft Tissue Paradigm in Orthodontic Diagnosis and Treatment Planning: A New View for a New Century', *J Esthet Dent,* 12 (2000), 46-9.
43 C. Sforza, C. Dolci, D. G. Tommasi, L. Pisoni, M. De Menezes, and F. Elamin, 'Three-Dimensional Facial Distances of Northern Sudanese Persons from Childhood to Young Adulthood', *J Craniomaxillofac Surg,* 42 (2014), e318-26.
44 J. R. Shaffer, E. Orlova, M. K. Lee, E. J. Leslie, Z. D. Raffensperger, C. L. Heike, M. L. Cunningham, J. T. Hecht, C. H. Kau, N. L. Nidey, L. M. Moreno, G. L. Wehby, J. C. Murray, C. A. Laurie, C. C. Laurie, J. Cole, T. Ferrara, S. Santorico, O. Klein, W. Mio, E. Feingold, B. Hallgrimsson, R. A. Spritz, M. L. Marazita, and S. M.

Weinberg, 'Genome-Wide Association Study Reveals Multiple Loci Influencing Normal Human Facial Morphology', *PLoS Genet,* 12 (2016), e1006149.
45 Affairs United States. Department of State. Bureau of Public, 'Zimbabwe', *Backgr Notes Ser* (1988), 1-8.

APPENDIX A

INSTITUTIONAL REVIEW BOARD

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:	KAU, CHUNG HOW
Co-Investigator(s):	BHASKAR, ELVIN
Protocol Number:	**X160406005**
Protocol Title:	*Soft Tissue Topographical Norms for the Local Ethnic People of Zimbabwe Based on 3DMD Soft Tissue Photography*

The IRB reviewed and approved the above named project on 5/9/16. 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: 5/9/16

Date IRB Approval Issued: 5/10/16

IRB Approval No Longer Valid On: 5/9/17

Expedited Reviewer
Member - 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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