Evaluation of Vertical Components of the Mandible Using Three-Dimensional Radiographs

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THESIS

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LIST OF ABBREVIATIONS

2D	Two-Dimensional
3D	Three-Dimensional
ANB	ANB Angle
ANOVA	Analysis of Variance
CBCT	Cone Beam Computed Tomography
cm	Centimeter
Co	Condylion
CT	Computed Tomography
CVS	Cervical Vertebral Maturation
DICOM	Digital Imaging and Communication in Medicine
FH	Frankfurt Horizontal
FH-MP	Frankfort Mandibular Plane Angle
FMA	Frankfort Mandibular Plane Angle
FOV	Field of View
Go	Gonion
ICC	Interclass/Intraclass Correlations
IBM	International Business Machines Corporation
IRB	International Review Board
LC	Lateral Cephalograms
mA	Milliampere
MBCA	Mandibular Base Convergence Angle
mm	Millimeter

Mn	Most Inferior Point of the Mandibular Notch
MP-SN	Mandibular Plane Angle (Mandibular Plane to Sella-Nasion)
MRI	Magnetic Resonance Imaging
OPRS	Office for the Protection of Research Subjects
PSNR	Peak Signal-to-Noise-Ratio
R	Right
RCH	Right Condylar Height
RCPH	Right Coronoid Process Length
RMRB	Right Minimum Ramus Breadth
RRB	Right Maximum Ramus Breadth
RRH	Right Ramus Height
L	Left
LCH	Left Condylar Height
LCPH	Left Coronoid Process Length
LMRB	Left Minimum Ramus Breadth
LRB	Left Maximum Ramus Breadth
LRH	Left Ramus Height
s	Second
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
ToCd	Most Superior Point of the Condyle
ToCd	Most Superior Point of the Coronoid Process
TMJ	Temporomandibular Joint

UIC	University of Illinois at Chicago
V	Voltage

SUMMARY

Components of mandibles are important elements that affect the vertical dimensions of the face, and the symmetry of the lower face. Due to the importance of the vertical dimension in orthodontic treatment, it is crucial to diagnose each patient accurately and provide the appropriate treatment plans to achieve the best treatment outcome. Recently, 3D CBCT imaging has gained its popularity due to its information and accuracy of linear and angular measurements on the patients' craniofacial structures. However, there is no extensive norm of 3D images compared to the existing 2D norms of lateral or antero-posterior cephalograms. To understand the morphology of mandibles of each craniofacial type and growth pattern, 3D CBCT would be a good tool to gain more information on various dimensions of mandibles, by evaluating the linear and angular measurements of its structure. The purpose of this study was to evaluate the association of various linear and angular parameters of subjects' mandibles with different craniofacial skeletal patterns, utilizing 3D CBCT images from three private practices.

Pre-treatment CBCT images from 331, non-growing subjects were used. Dolphin Imaging Software was utilized for 2D cephalometric analysis, categorizing the samples, measuring the 3D CBCT images, and measuring the 2D generated cephalometric images. The samples were grouped into Class I, Class II, and Class III skeletal types; and subgrouped into hyperdivergent, normodivergent, and hypodivergent, based on their cephalometric analysis. Differences in ramus height, ramus breadth, condylar length, coronoid process length, anterior mandible height, and convergence angles of the ramus and of the mandibular base amongst the

skeletal categories were evaluated. Statistical analyses were conducted to determine differences of the outlined variables amongst the skeletal types.

The results demonstrated that a significant difference in ramus height was observed between Class I and III skeletal types, and between males and females. Among the vertical patterns of the Class I skeletal group, ramus height, anterior mandibular height, and convergence angle of mandibular base, showed significant differences. The positive correlation of various parameters of the mandibles was observed the most in normodivergent subjects, compared to other growth patterns. Among the vertical patterns of the Class II skeletal group, ramus height, condylar height, anterior mandibular height and convergence angle of mandibular base showed significant differences, while all parameters except minimal ramus breath on the left side showed no significant difference in the Class III skeletal types. Higher ramus height and anterior mandibular height were observed in males compared to the ones in females, in all skeletal types and growth patterns. No difference was found between the ramus height of the 2D cephalometric orthogonal projection and the average of the 3D right and left ramus heights, in all skeletal types except Class I normodivergent and hypodivergent; however the mean differences were clinically insignificant.

The results in this study provide preliminary norms of skeletal parameters for 3D CBCT images of various skeletal types, and could be beneficial as a tool for future orthodontic treatment planning, using 3D CBCT.

1. INTRODUCTION

1.1. Background

The height of the mandibular ramus and condyle are important elements that affect the vertical dimensions of the face, and the symmetry of the lower face. Due to the importance of the vertical dimension in orthodontic treatment, there is clinical importance in diagnosing hyperdivergent, normodivergent, and hypodivergent facial types. Various facial types require different orthodontic biomechanics. The direction of growth of the mandible, can have a crucial effect on the type of biomechanics appropriate for orthodontic treatment. Thus, orthodontists take great interest in the differences between the diagnosis, treatment, and treatment outcomes of hyperdivergent, normal, and hypodivergent facial types. (Mangla et al., 2011)

A study by Markic in 2015, compared commonly used radiographic techniques, and their accuracy and precision in measuring different mandibular components. The study showed that measurement precision was the highest for panoramic radiographs, followed by cone-beam computed tomogram (CBCT), computed tomogram, magnetic resonance imaging, and lateral cephalogram. Panoramic radiographs proved to be highly sensitive to positioning issues that can lead to magnification errors and disproportional enlargement. Three-dimensional images were proved to be just as, if not more, reliable and accurate as two-dimensional radiographs for measuring vertical components of the mandible. (Markic et al., 2015)

The measurements and information obtained from radiographs, regarding the vertical components of a patient's craniofacial skeleton, plays an important role in a successful orthodontic treatment plan. This study will evaluate the association of linear and angular measurements of the mandible, with the craniofacial patterns of the population samples.

1.2. Specific Aims

The purpose of this study is to three-dimensionally evaluate the vertical components of a patient's mandible, and its relationship with various craniofacial measurements using CBCT images. The objectives of this study are to: determine the difference in ramus height, condylar height, and coronoid process length, anterior mandibular height, and ramus breadth measurements among hyperdivergent, normodivergent, and hypodivergent vertical types in Class I, Class II, and Class III skeletal types; to determine the difference in the convergent angle of ramus and convergent angle of the mandibular base among hyperdivergent, normodivergent, and hypodivergent vertical types in Class I, Class II, and Class III skeletal types; and to determine the accuracy of ramus height measurements between 3D generated CBCT images versus 2D cephalometric radiographs.

1.3. Null Hypotheses

1. There is no mean difference on the studied variables among the factors: vertical growth patterns (hyperdivergent, normodivergent and hypodivergent), sex (males and females) and race (Caucasian and Hispanic).

    1.1 There is no significant difference of the ramus height, ramus breadth, condylar height, coronoid process length, and anterior mandibular height among hyperdivergent, normodivergent, and hypodivergent samples in the Class I, Class II, and Class III skeletal types.

1.2 There is no significant difference of the convergence angles of the ramus and the mandibular base of among the hyperdivergent, normodivergent, and hypodivergent samples in the Class I, Class II, and Class III skeletal types.

2. There is no mean difference between the measurements for ramus height using the three-dimensional rendered image from CBCT scans, and the two-dimensional orthogonal generated lateral cephalometric image of the hyperdivergent, normodivergent, and hypodivergent samples in the Class I, Class II, and Class III skeletal types, male and female.

2. REVIEW OF LITERATURE

2.1. Vertical Components of the Mandible

Skeletal growth is a key component of development, and the field of orthodontics puts great emphasis on this. For the clinical orthodontist, it is imperative to be familiar with the knowledge of craniofacial growth and development. Variations in the development of the craniofacial complex lead to malocclusions, and various changes in the relationships of the maxilla and mandible. Changes in one portion of the craniofacial complex, will lead to compensation or changes in another portion. One of the most important features of the mandibular ramus is to provide attachments for the muscles of mastication, but it also plays an important role in placing the mandibular body and dental arch in a balanced position with the maxilla and the other craniofacial structures. This harmonious positioning is maintained by the remodeling of the ramus to give its proper alignment, vertical length, and antero-posterior dimensions. A report showed that high or low mandibular plane angle (MP-SN) was not accompanied by long or short anterior face height. The posterior facial height, determined by ramus height, was assumed to play a key role in the vertical facial height types. (Wang et al., 2013) Thus, the development of the ramus is an integral component of craniofacial growth. (Yassir, 2013)

2.2. Two Dimensional Radiographs

The introduction of lateral cephalometric radiographs brought an increase in the interest in variations of facial types and patterns. This introduction made it possible to study various facial types, with emphasis on their association with malocclusions and skeletal relationships. (Mangla et al., 2011) Although 2D cephalometry has proven to be one of the most significant advancements of the orthodontic field, it has its disadvantages. The common disadvantages of two-dimensional imaging include the lack of dimensional perspective, errors in projection, magnification variations, voids in information, and sensitivity to head positioning. The realization that there is a 3D anatomic reality that is not present with 2D imaging, has been evident since the inception of radiographic cephalometry. (Berco et al., 2009)

2.3. Ramus Height Norms

Research has been conducted on ramus height, and its relationship to facial height. In a study conducted by Yassir et al (2013), ramus height measurements were correlated to dental and skeletal relationships. As a result of this study, it was concluded that ramus height was directly correlated with posterior facial height, and inversely correlated with the angles of mandibular rotation. Another finding of this study proved that, shorter ramus heights presented with higher gonial angles and longer ramus heights presented with smaller gonial angles. (Yassir, 2013)

Studies have also shown that, mandibles with a vertical growth pattern are commonly associated with decreased ramus height and width. When compared with hyperdivergent growers, the height of the ramus has been found to be significantly increased in hypodivergent and normodivergent growers. (Mangla et al., 2011) Studies have shown that high or low mandibular plane angle (MP-SN) has not been accompanied by long or short anterior facial height, but that the posterior facial height, determined by ramus height, was assumed to play a key role in the vertical facial height types. (Wang, Otsuka, Akimoto, & Sato, 2013)

2.4. Ramus Height and Sex Determination

Male bones are generally bigger and more robust than female bones. The development in size, strength, and angulation of the muscles of mastication, has a direct influence on mandibular dimorphism due to the forces of mastication being different in males and females. As a result of this difference in masticatory force, the height and structure of the ramus has shown to be effected. Through scientific research studies, the mandibular ramus has been considered a valuable tool in sex determination. (Indira, Markande, & David, 2012)

The mandibular ramus can be used to determine male and female sex, especially after puberty. It has been shown that sites of bone remodeling have some of the greatest potential for sexual dimorphism. The mandibular condyle and ramus are two skeletal structures associated with the greatest changes in size during remodeling and growth. (Samatha et al., 2016)

Sex determination using 3D CBCT radiographs is advantageous to conventional radiographic techniques, due to the undistorted and high-quality images that are produced with low radiation doses. This allows for precise identification of bony structures. (Dong et al., 2015)

2.5. Three-Dimensional CBCT Imaging

Several studies compared various radiographic imaging techniques, and their accuracy and precision with measurements for the ramus height and condylar process length. The techniques commonly used to measure the components of the mandible are computed tomography (CT), cone beam computed tomography (CBCT), magnetic resonance imaging (MRI), lateral cephalograms (LC), and panoramic radiographs. CT has been typically considered to be the gold standard for bony measurements, but it involves the highest radiation exposure. A study by Markic et al in 2015 compared the commonly used radiographic techniques, and their accuracy and precision in measuring mandibular components. The study showed that measurement precision was the highest for panoramic radiographs, followed by CBCT, CT, MRI, and LC. However, the panoramic radiographs proved to be highly sensitive to positioning issues that can lead to magnification errors and disproportional enlargement. LC measurements showed the worst results for precision. In contrast with three-dimensional imaging techniques, the lateral cephalogram is a two-dimensional radiograph in which the three-dimensional structures are projected onto a two-dimensional plane. This method makes it difficult, and nearly impossible to distinguish between opposing structures, and complicates locating critical landmarks for measuring purposes. Three-dimensional imaging proved to be just as, if not more, reliable and accurate as two-dimensional radiographs for measuring vertical components of the mandible. (Markic et al., 2015)

Many dental specialties routinely utilize CBCT imaging, but historically that has not been the case for the field of orthodontics. Past reasons for the lack of use included technological limitations, high costs, and exposure dosage to radiation. In addition, only a few studies have been done to assess the accuracy of linear measurements on 3D images. There have been advances in technology that now make it realistic to begin utilizing CBCT imaging as the standard of care in orthodontic diagnosis and treatment planning. The only thing to truly push this realization is through scientific studies depicting its accuracy and reliability. (Berco et al., 2009)

2.6. Two-Dimensional Images Generated from Three-Dimensional CBCT Images

Obviously, when generating 2D radiographs from a 3D CBCT radiograph, the 3D characteristics are lost due to the 2D representation of 3D structures on the radiograph. The future of cephalometry will be 3D cephalometric norms, analysis, and diagnosing on a 3D radiographic model of the patient's skull. In the meantime, it is imperative to know whether the traditional 2D cephalometric analysis and diagnosing can be compared with measurements on a 3D model derived for 3D analysis, which will be more common in the years to come. (van Vlijmen et al., 2010)

When generating a two-dimensional cephalometric radiograph from a 3D CBCT radiograph, there are different projection options that can be applied. Two projection options allotted in the Dolphin 3D software are orthogonal projection and perspective projection. Generating a perspective projection, lateral 2D image from a 3D CBCT scan, allows the operator to accurately reproduce the built-in magnification of a conventional 2D lateral cephalogram. This generated 2D image can be used to compare data with traditional normative values. (Lamichane, Anderson, Rigali, Seldin, & Will, 2009)

Although the perspective projection reproduces the built-in magnification of a conventional 2D lateral cephalogram, the orthogonal CBCT projection produces images closer to the actual size reflected in the skull and is a more precise image. The decrease in precision found in the perspective projection, is due to the magnification and distortion inherently applied to the projection. (Montúfar, 2016)

The peak signal-to-noise-ratio (PSNR) is able to measure the difference between digitally reconstructed radiographs and conventional digital radiographs. According to the study by Montúfar et al. in 2016, the PSNR values of both the orthogonal and perspective projections of digitally reconstructed radiographs proved to be similar to a conventional radiograph, and both can be used to perform a cephalometric analysis. Images generated using the orthogonal projection, provided greater accuracy in the identification of sagittal cephalometric landmarks than perspective projection images and conventional cephalometric images. The orthogonal perspective utilizing no magnification, allows for an actual match to the original CBCT. (Montúfar, 2016)

2.7. <u>Mandibular Ramus and Three-Dimensional CBCT</u>

Cone-beam computed tomography (CBCT) imaging was first introduced to dentistry in the United States at Loma Linda University, in 2000. CBCT imaging has proven to be a modern advancement in dentistry, providing three-dimensional representations of craniofacial structures for diagnosing, treatment, as well as research purposes. (Berco et al., 2009)

CBCT imagining is a favorable method for assessing the craniofacial skeleton in 3D. A study by Zhang et al in 2013, aimed to evaluate the condyles in growing adolescents. According to this study, the values for right and left condylar height, and right and left ramus height were significantly different among Class I, Class II, and Class III skeletal groups. There was a statistically significant difference between the Class I and Class II skeletal groups for right and left condylar height, and right and left ramus height; with the Class I skeletal group presenting with higher means for these variables. There was also a statistically significant difference between the Class II and Class III skeletal groups for right and left ramus height, with the Class III skeletal group presenting with higher means for these variables. (Zhang et al., 2013)

2.8. Clinical Implications for Three-Dimensional CBCT Research on the Mandibular Ramus

Traditional 2D cephalometric radiographs have long been a standard diagnostic tool for analyzing maxillofacial norms and anomalies, diagnosing orthodontic problems, and evaluating growth and/or treatment changes. With the introduction of 3D CBCT imaging, there has been an increased popularity and interest in the technology. This technology has proven to generate realistic images of the skull, and thus serve as an aid in surgical and orthodontic procedures. Traditional 2D cephalograms seem to be compromised tools for the diagnosing and treatment planning of orthognathic cases, and patients with craniofacial anomalies. (van Vlijmen et al., 2010)

2.8.1. Growth prediction

Various facial types require different orthodontic biomechanics. One reason why biomechanics is a very important component of orthodontic treatment is due to the amount and direction of facial growth and development. This important variable of facial growth and development has a direct correlation to proper diagnosis, treatment planning, and treatment outcomes in normodivergent, hyperdivergent, and hypodivergent facial types. With the introduction of lateral cephalograms, an interest in the various facial types increased, by placing emphasis on their association with malocclusion and skeletal relationship. (Mangla et al., 2011)

Given the importance of facial growth to the practice of orthodontics, the ability to predict this growth is very suitable for the clinical orthodontist. In order to accomplish this, there has to be foundational knowledge of mandibular growth and its relationship to diagnosing, treatment planning, and its importance in a balanced and harmonious dentofacial complex. (Mangla et al., 2011)

2.8.2. Orthognathic Surgical Cases

It is important to assess mandibular morphology when orthognathic surgical procedures, such as mandibular ramus osteotomies, are performed. Three-dimensional CBCT radiographs make it possible to find the differences in condylar process height between right and left sides, and make it possible to evaluate any possible deviations that need to be addressed prior to a successful surgical outcome. (Inoue et al., 2015) However, until now there is no reported norm for ramus or condylar height in 3D.

2.8.3. Asymmetrical & Hemifacial Microsomia Patients

There have been few studies on asymmetrical cases, such as unilateral hemifacial microsomia. (Suzuki et al., 2017) The condyle is an important growth center in the mandible that can regulate the direction and rate of mandibular growth. Asymmetry of the face occurs when the development of different regions is not evenly balanced, and results in chin deviations, midline shifts, contralateral crossbites, and/or occlusal cants. Congenital abnormalities, acquired diseases, trauma, and developmental deformities may cause this asymmetry. CBCT technology can be utilized in these cases to interpret 3D images that can allow surface and volumetric measurements with high accuracy, in orthogonal projections. (Zhang et al., 2013)

The study by Zhang et al. in 2013, also evaluated the association of condylar asymmetry and chin position with Class I, Class II, and Class III skeletal patterns in a sample of growing Chinese adolescents, using 3D CBCT images. The results of the study showed that the difference in values between the right and left sides for condylar vertical position and ramus height, were positively correlated with a shift in the chin position. (Zhang et al., 2013)

2.8.4. Temporomandibular Joint

One of the most important joints in the body is the temporomandibular joint (TMJ). This joint is important because it is closely related to the oral cavity and the teeth. The condyle, which comprises a significant part of the joint, has a position and function that is controlled primarily by the structures of the oral cavity, as well as the musculature associated with this region. Not only can the treatment provided by orthodontic specialists influence the position of the condyles, but also any abnormalities prior to or during treatment, can play an important role in proper orthodontic treatment planning. As a center of growth in the mandible, the condyle readily responds to continuous stimuli during the growth and remodeling process. It is clear to see how the condyle plays an important role in the final dimensions of the adult mandible. Studies have reported high accuracy in measuring the bony structures of the TMJ, using 3D CBCT imaging. (Al-koshab, Nambiar, & John, 2015)

2.8.5. <u>Forensics & Anthropology</u>

Sex determination by evaluating skeletal remains is standard in forensic science. (Inci et al., 2016) The pelvis is the most dimorphic skeletal bone, being able to assign sex with almost 100% accuracy. The skull follows as a close second, with over 90% accuracy. The mandible is the most dimorphic bone of the skull, and is usually well preserved for use in sex and race determination in forensics and archaeological cases. (Dong et al., 2015)

The identification of skeletal and decomposing remains continues to be a difficult skill. There have been studies that focus on various skeletofacial characteristics, leading to dimorphic criteria that can aid in the identification of an unknown body. Ramus height is one of the measurements that have been reported to show dimorphism among the sexes. Utilizing CBCT technology, accurate linear measurements of the components of the mandibular body have been produced using reliable 3D imaging of the craniofacial skeleton. (İlgüy, İlgüy, Ersan, Dölekoğlu, & Fişekçioğlu, 2014) Modern 3D radiology, offers significant potential for sex determination. In tandem with methods utilizing anthropological measurements, the increasing number of clinical 3D radiographs can be used for anthropologic data of modern populations.

The mandible's size and solid structures, provides valuable data for sex determination purposes. A study by Inci et al in 2015, evaluated the CT scans of 415 Turkish patients, aged 18-60 years old. In this study, maximum ramus vertical height proved to be a measurement of the mandible showing over an 80% accuracy value for sex determination. (Inci et al., 2016)

3. METHODOLOGY

3.1. Study Design

This is a study that will evaluate initial CBCT images of non-growing patients. These patients were categorized with Class I, Class II, and Class III skeletal patterns, and further categorized as having hypodivergent, normodivergent, and hyperdivergent skeletal patterns. The criteria for the classification of vertical skeletal patterns used in this study, was modified from the developed method of Markic et al in 2015. Two-dimensional cephalometric radiographs were generated from three-dimensional CBCT radiographs, to categorize the samples according to skeletal type. Three-dimensional measurements were used for the evaluation of ramus height, condylar height, coronoid process length, maximum and minimum ramus breadth, anterior height of the mandible, convergence angles of the ramus, and convergence angle of the base of the mandible. The obtained measurements were compared amongst the categorized skeletal groups. In addition, a final measurement of two-dimensional ramus height measured from the two-dimensional generated lateral cephalometric image, were compared with the three-dimensional measurement for ramus height.

3.2. IRB Approval

A "Claim of Exemption" application was submitted to the UIC Office for the Protection of Research Subjects. The UIC OPRS determined on April 27, 2017 that this study did not qualify for an exemption since the data was not de-identified, but instead coded. As a result, the submitted protocol was given an "Expedited Review" under the expedited IRB review procedures, and was approved for the study to begin, as shown in Appendix.

3.3. Material and Methods

This study was carried out in the computer laboratory of the orthodontic department of the University of Illinois at Chicago. The CBCT scans were obtained from three private orthodontic practices in Illinois and Colorado. A pre-treatment CBCT scan was taken for each subject prior to the initiation of orthodontic treatment. The inclusion criteria was as follows:

- Subjects with fully erupted permanent dentition, with at least one molar in each quadrant to support the vertical dimension were selected for this study.
- Subjects between twenty and forty-five years of age, and a CVS V classification were selected, due to growth being complete.
- Subjects were also screened for no history of craniofacial anomalies, no prior orthodontic or orthopedic treatment, and no history of drugs that affects the bone or craniofacial growth.

The private orthodontic practices of Dr. Bradford Edgren in Greeley, Colorado; Dr. Terry Sellke in Grayslake, Illinois; and Dr. Ronald Jacobson in Chicago, Illinois were used to obtain CBCT scans. The specification and dosage of each CBCT unit utilized in each practice is shown in Table 1. The machines were equipped with a chair and head support so that each patient was scanned while sitting in an upright position, utilizing a mirror and laser beam light to ensure a natural head position. Participants were also instructed to rest the tongue in a relaxed position touching the top of the palate, breathing lightly through their noses, to avoid swallowing, and position the mandible in maximum occlusal intercuspation.

Table 1. CBCT Unit Specifications and Dosages

	Bran d	Voltage (V)	Amp (mA)	FOV (cm2)	Voxel size (mm3)	Scan time (s)
Dr. Sellke	i-CAT	120	5	16x13	0.4	8.9
Dr. Jacobson	i-CAT	120	5	16x13	0.3	4.8
Dr. Edgren	i-CAT	120	5	16x13	0.3	7

The patients' demographic information was obtained as part of the doctor's examination process and clinical examination. All of the obtained CBCT files and images were de-identified by the staff of the three private practices, and transferred to the portable hard disk. Each image was de-identified by an assigned numerical code representing sex, date of birth, race, and last name. A master list that matched the scan's code with the personal identifiers (sex, date of birth, race, and last name) was secured in a locked cabinet at the orthodontic office in Greeley, Colorado; Grayslake, Illinois; and Chicago, Illinois. Once the study was complete, the master list and the personal identifiers were destroyed.

The de-identified CBCT images were in DICOM (Digital Imaging and Communications in Medicine) format. The images were imported into the Dolphin Software (Version 11.9; Dolphin Imaging and Management Solutions, Chatsworth, Calif). The three-dimensional component of the software was used to orient each three-dimensional image to Frankfort's horizontal on both right and left sides in the sagittal plane. (Figure 1) The axial plane was constructed through the interpupillary line, and the coronal plane was constructed through a line perpendicular to the sella-nasion line. (Figure 1) Using the sagittal, axial, and coronal views, the skull was oriented three dimensionally. (Figure 2)

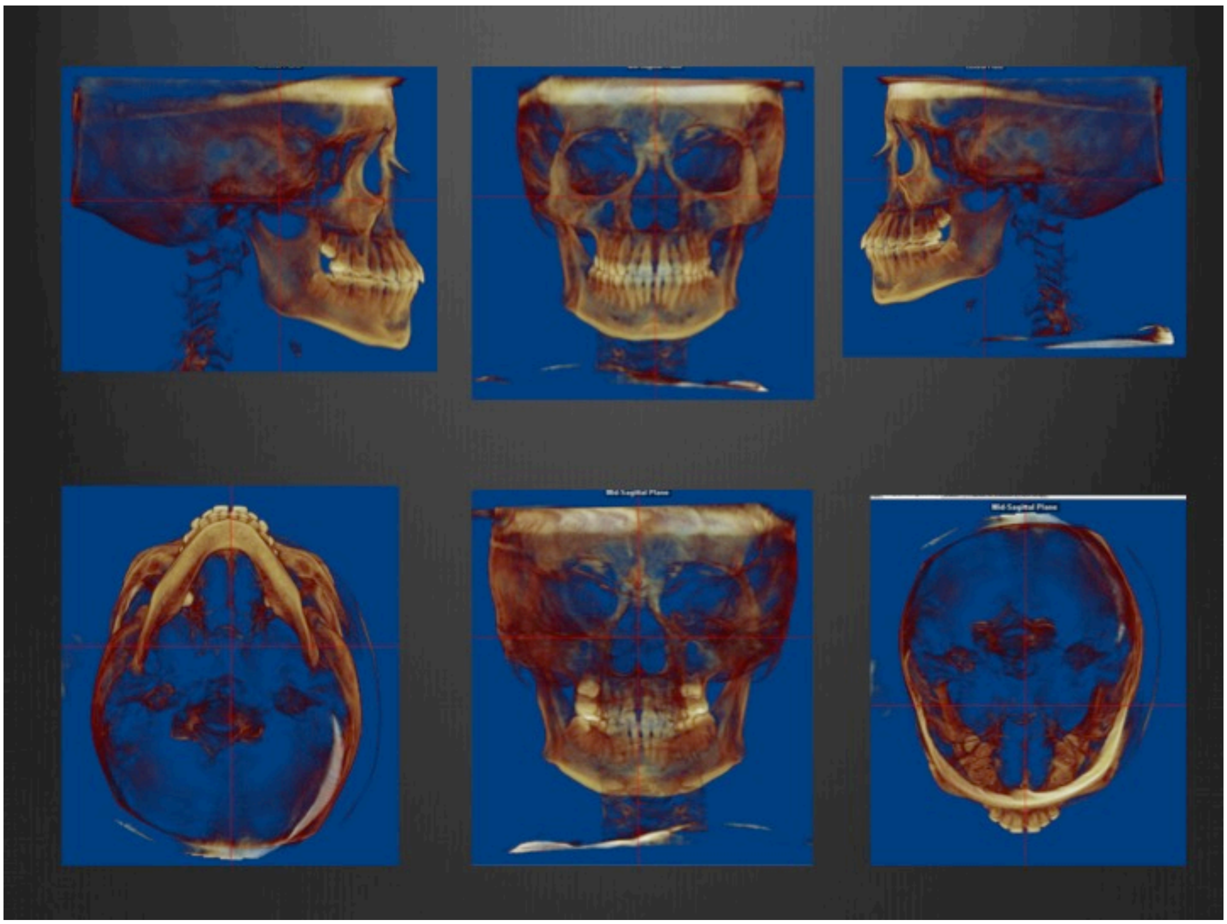


Figure 1. Three-Dimensional Orientation

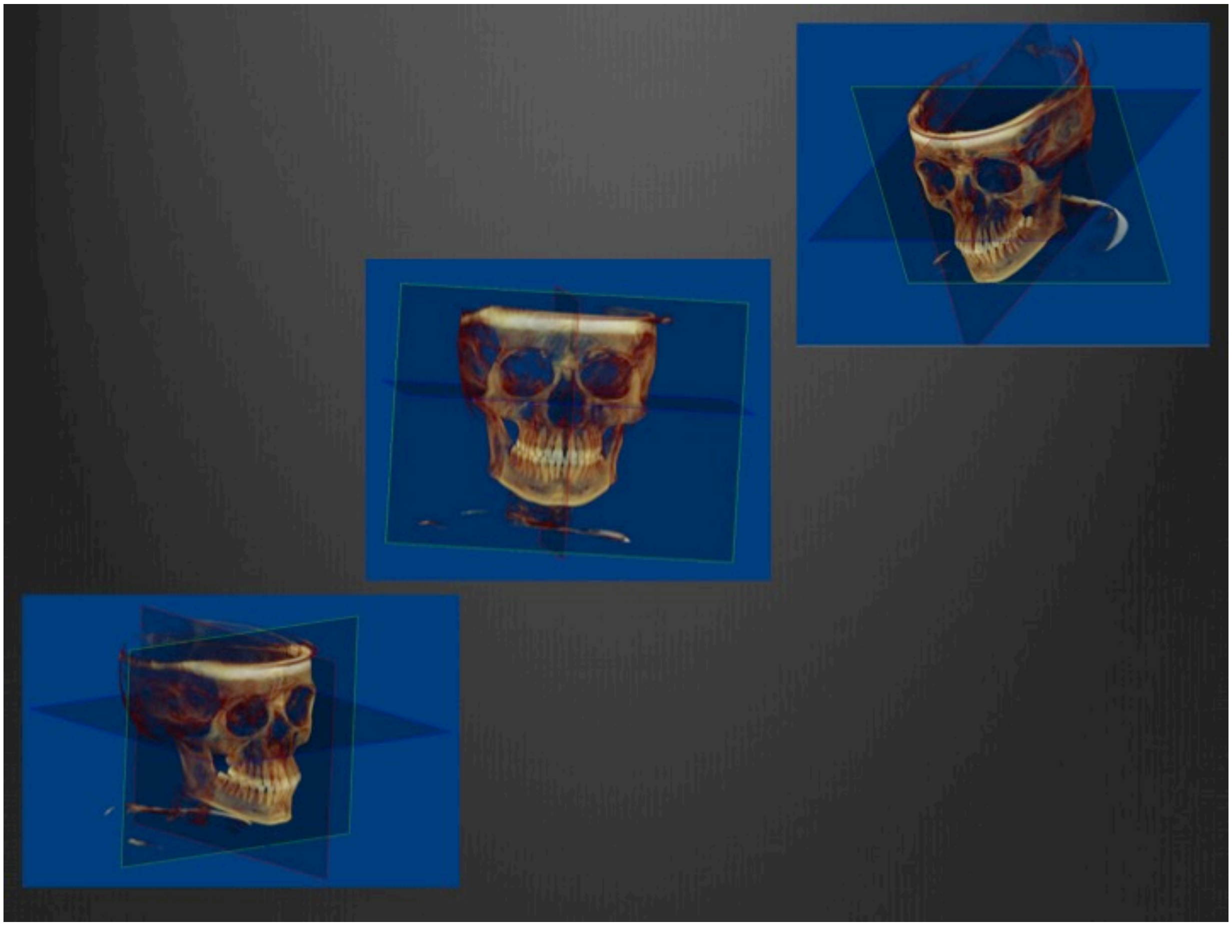


Figure 2. Three-Dimensional Planes of Space

After the process of image orientation was complete, a two-dimensional (2D) lateral cephalogram in orthogonal projection was generated from each CBCT scan in the Dolphin Imaging Software. (Figure 13) A cephalometric tracing and analysis was then performed using the Dolphin software. After the cephalometric analyses, the images were categorized into various skeletal pattern groups. The images were categorized by hyperdivergent, normodivergent, and hypodivergent vertical skeletal patterns; and also categorized as Class I, Class II, and Class III antero-posterior skeletal types, as shown in Table 2.

Table 2. Criteria for Definition of Various Skeletal Patterns (Nation, 2016)

Term	Definition
Hyperdivergent	Frankfort Mandibular Plane Angle (FH-MP) > 29°
Hypodivergent	Frankfort Mandibular Plane Angle (FH-MP) < 23°
Normodivergent	Frankfort Mandibular Plane Angle (FH-MP) 23-29°
Class I skeletal	ANB 0-5.9°
Class II skeletal	ANB ≥ 6°
Class III skeletal	ANB < 0°

Initially, a total of 445 CBCT images, were obtained from the three private orthodontic offices. A total of 114 subject images were eliminated in this study, due to the inclusion criteria. Some images were eliminated, due to not having all two-dimensional structures captured during their scan to ensure a complete cephalometric tracing and analysis, and also eliminated due the scans being captured while under active orthodontic treatment. As a result, a total of 331 subject images were utilized for the study.

Measurements of variables on the three-dimensional CBCT images were performed. Right and left ramus height (RRH, LRH), right and left condylar height (RCH, LCH), right and left coronoid process length (RCPH, LCPH), right and left maximum ramus breadth (RRB, LRB), right and left minimum ramus breadth (RMRB, LMRB), anterior mandibular height (AMH), right and left ramus convergence angle (RRCA, LRCA), and mandibular base convergence angle (MBCA) measurements were performed amongst hyperdivergent, normodivergent, and hypodivergent groups of Class I skeletal patterns; hyperdivergent, normodivergent, and hypodivergent groups of Class II skeletal patterns; and hyperdivergent, normodivergent, hypodivergent groups of Class III skeletal patterns.

The mandible of each image was separated from the skull, utilizing the sculpting tool in Dolphin 3D (Version 11.9; Dolphin Imaging and Management Solutions, Chatsworth, Calif). After the separation process was complete, 16 landmarks were placed on identifying structures of the mandible (Figures 3-5, Table 3). These structures were utilized to complete the linear and angular measurements.

Table 3. List of Three-Dimensional Skeletal Landmarks

Landmarks	**Definition**
ToCd (right and left)	Most superior point of the condyle
ToCr (right and left)	Most superior point of the coronoid process
Gonion (right and left)	Lowest, most lateral point on the angle of the mandible
Mn (right and left)	Most inferior point of the mandibular (sigmoid) notch
Convex Point of Anterior Edge of Mandibular Coronoid Process (right and left)	Most protruding point of the anterior margin of the mandibular coronoid process
Posterior Point of Mandibular Condyle (right and left)	Most protruding point of the posterior margin of the mandibular condyle
Concave Point of Anterior Edge of Mandibular Ramus (right and left)	Most concave point of the anterior spine of the mandibular ramus
Concave Point of Posterior Mandibular Ramus (right and left)	Most concave point of the posterior edge of the mandibular ramus
Superior Anterior Alveolus	Most superior point on the anterior alveolus, at the skeletal midline
Inferior Anterior Alveolus	Most inferior point on the anterior alveolus, at the skeletal midline

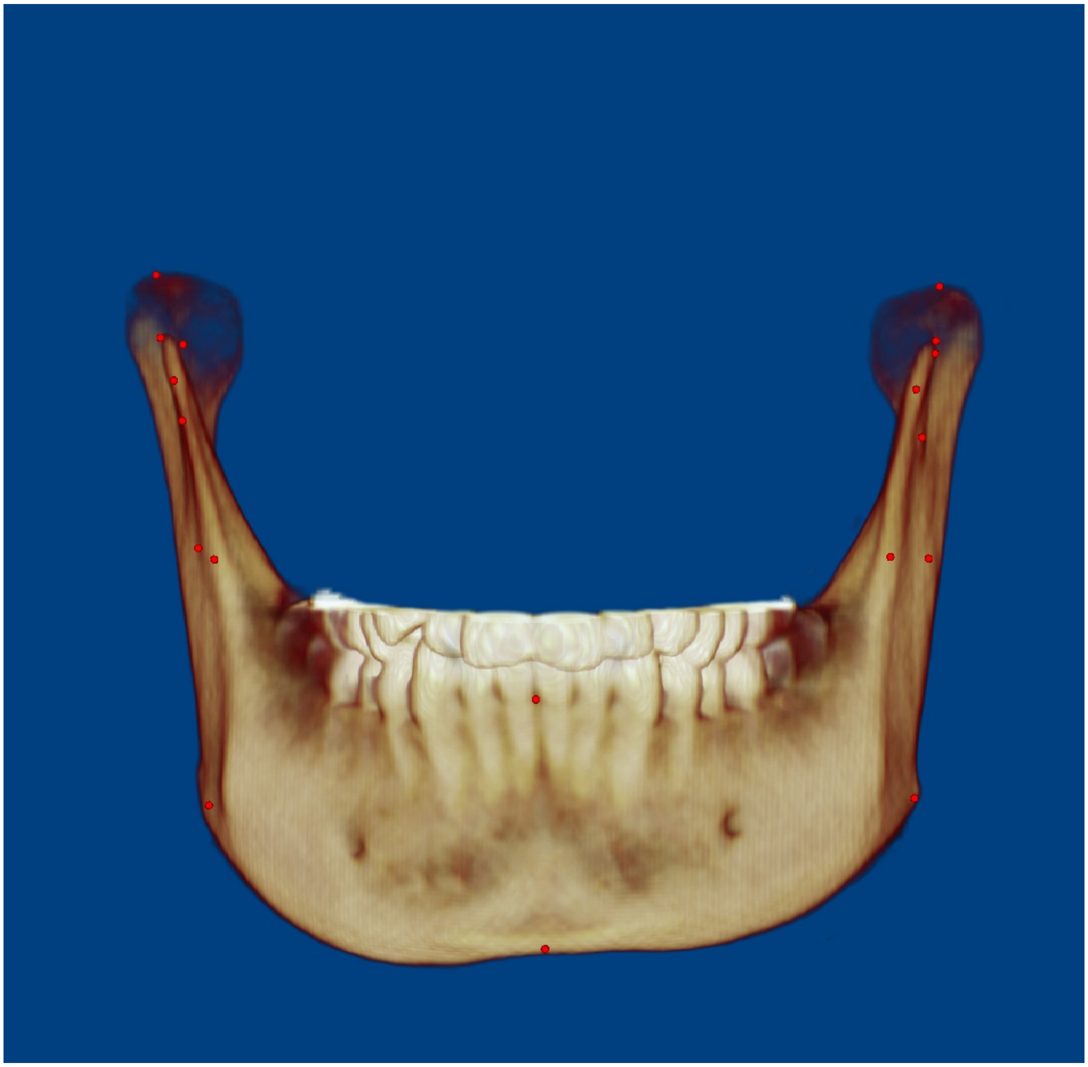


Figure 3. Three-Dimensional Skeletal Landmarks, Frontal View

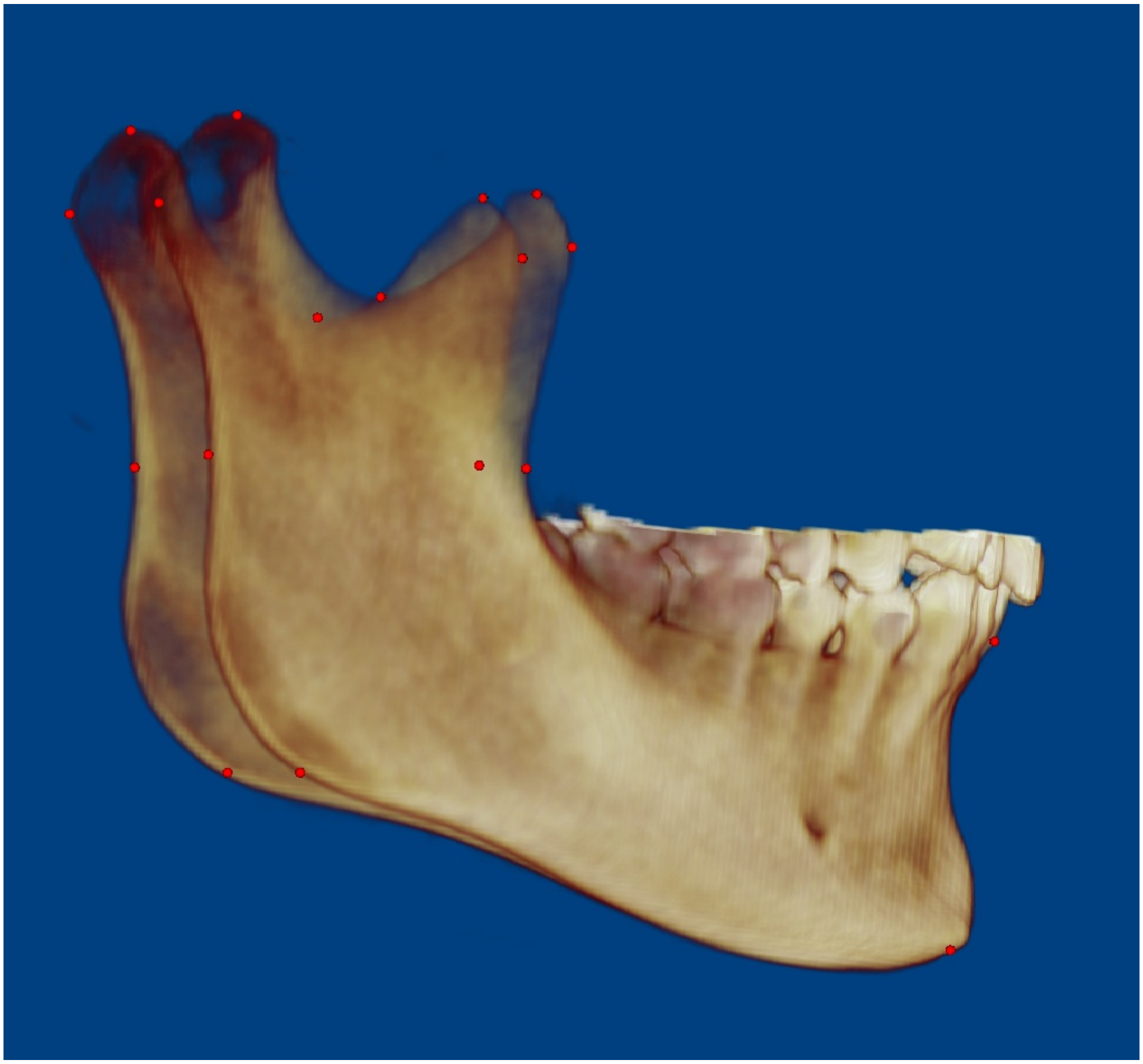


Figure 4. Three-Dimensional Skeletal Landmarks, Right-Side View

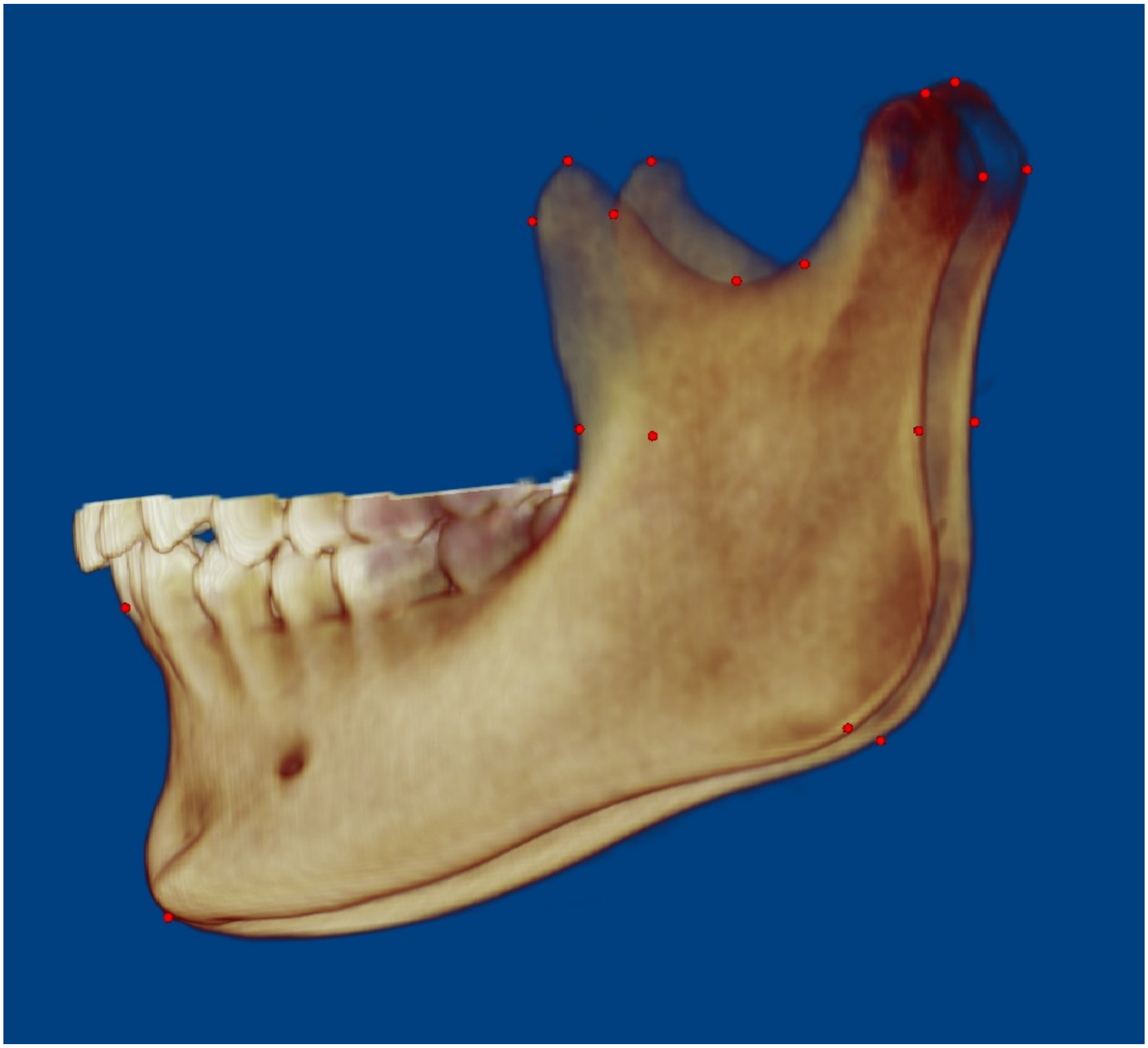
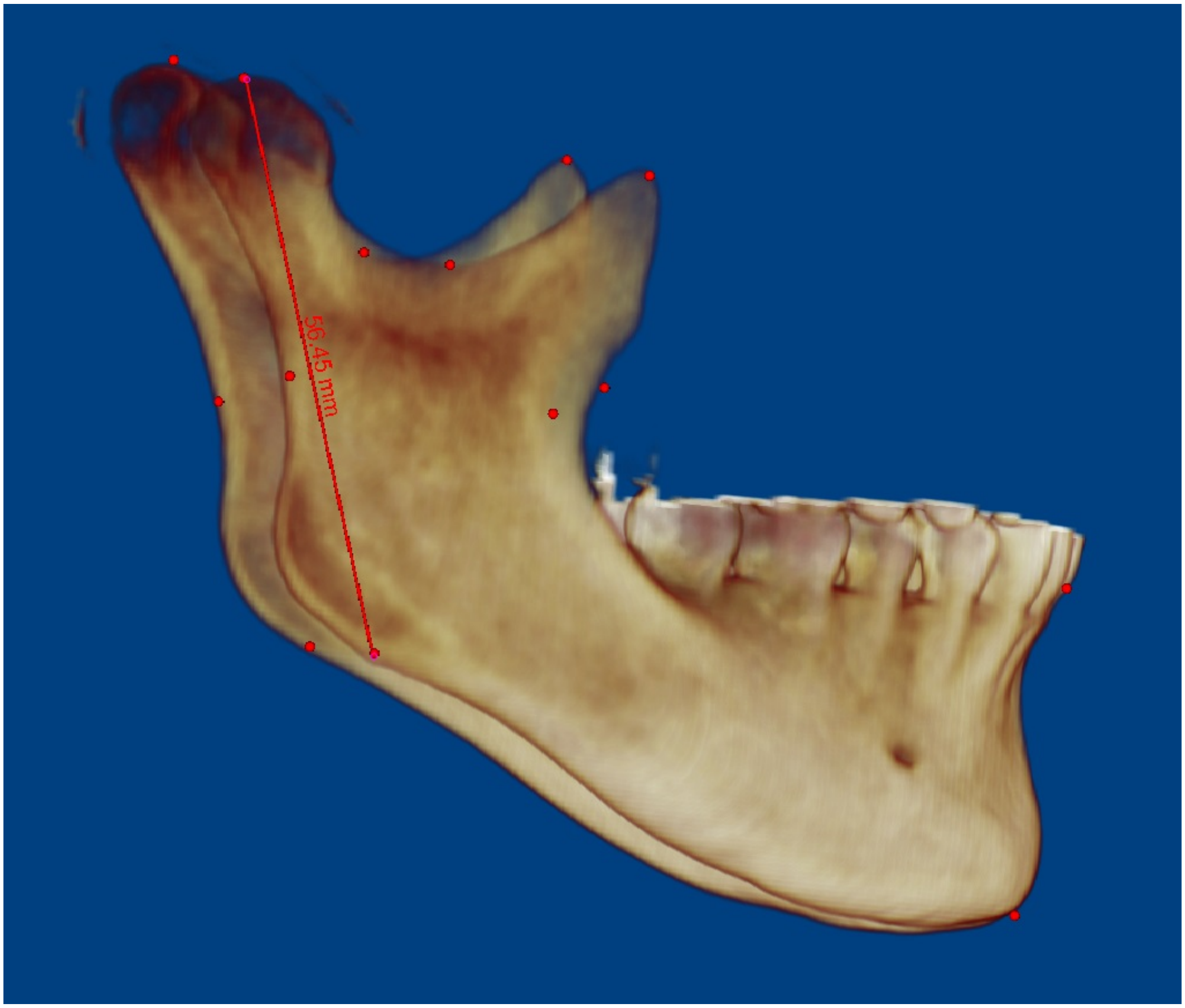


Figure 5. Three-Dimensional Skeletal Landmarks, Left-Side View

To measure the three-dimensional right ramus height, a line was drawn from the right-side landmark representing the top of the condyle (ToCd), to the right-side landmark representing gonion (Go). The software produced a linear millimeter measurement. The same measurement was done for the left side (Figure 6).

Figure 6. Three-Dimensional Ramus Height



In order to measure the three-dimensional right condylar height, an angular measurement of ninety degrees was drawn from the top of the condyle, to the mandibular notch (Mn). A line was then drawn from the right-side landmark representing the top of the condyle (ToCd), to the right-side angular point where the angle between the top of the condyle and the mandibular notch measured ninety degrees. The software produced a linear millimeter measurement. The same measurement was done for the left side (Figure 7).

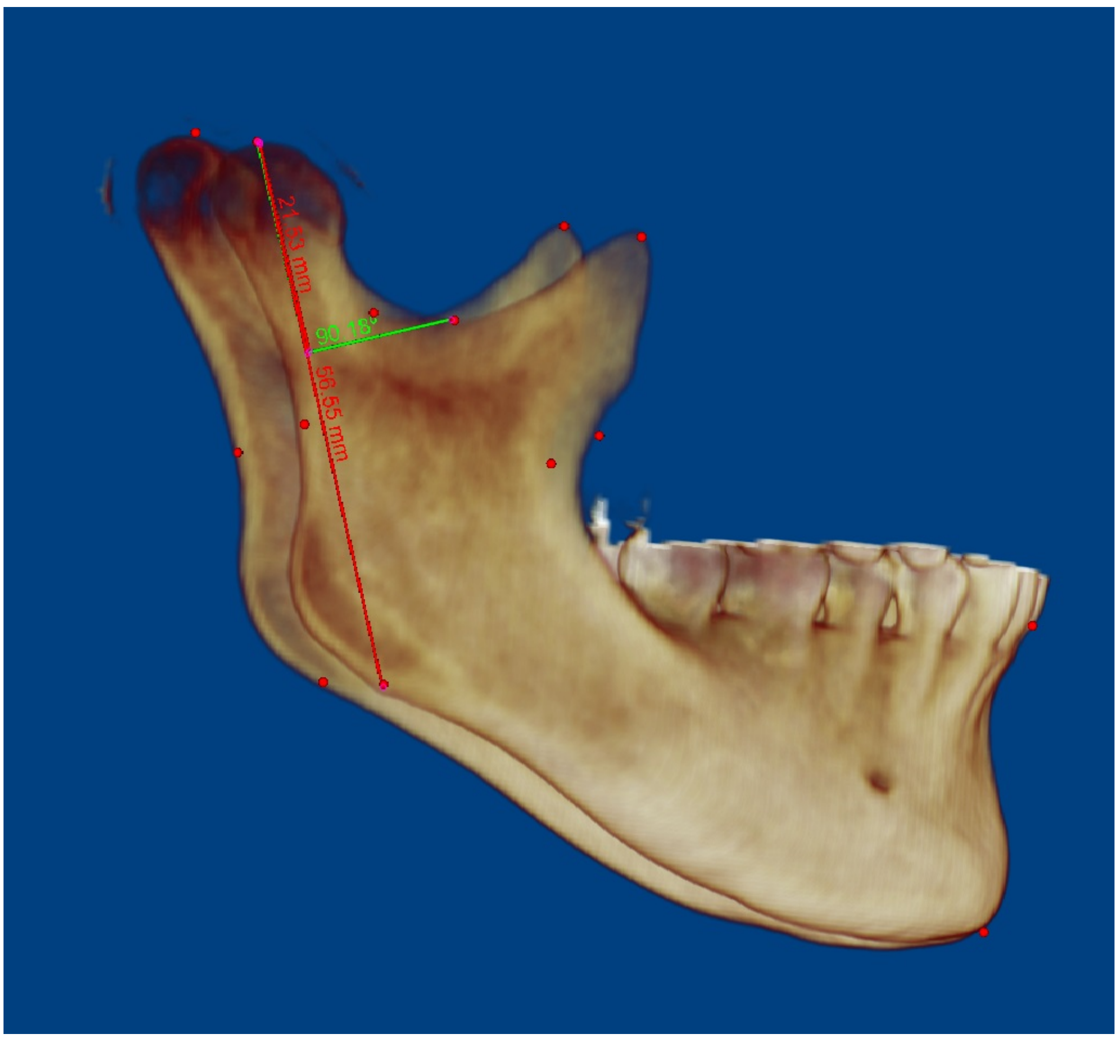


Figure 7. Three-Dimensional Condylar Height

Right and left coronoid process length was measured by drawing a line from the right-side landmark representing the top of the coronoid (ToCr), to the right-side landmark representing gonion (Go). An angular measurement of ninety degrees was then drawn from the top of the coronoid, to the mandibular notch (Mn). A line was then drawn from the right-side landmark representing the top of the coronoid (ToCr), to the right-side angular point where the angle between the top of the coronoid and the mandibular notch measured ninety degrees. The software produced a linear millimeter measurement. The same measurement was done for the left side. (Figure 8)

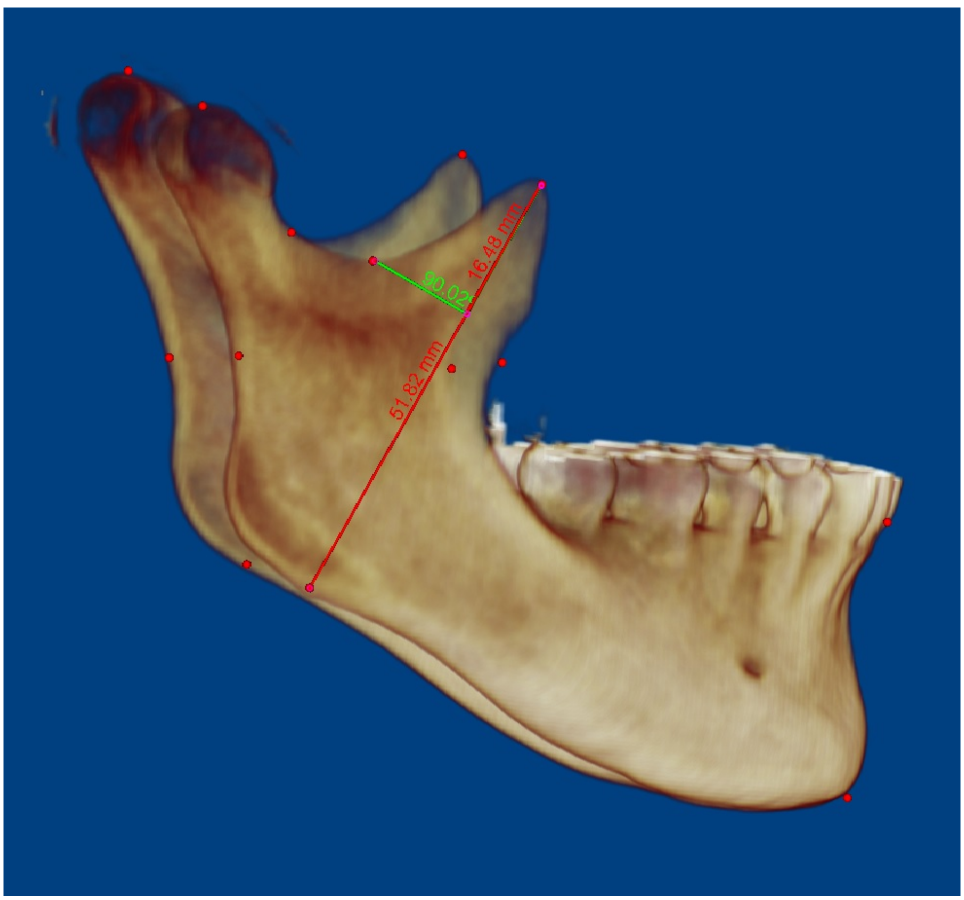


Figure 8. Three-Dimensional Coronoid Process Length

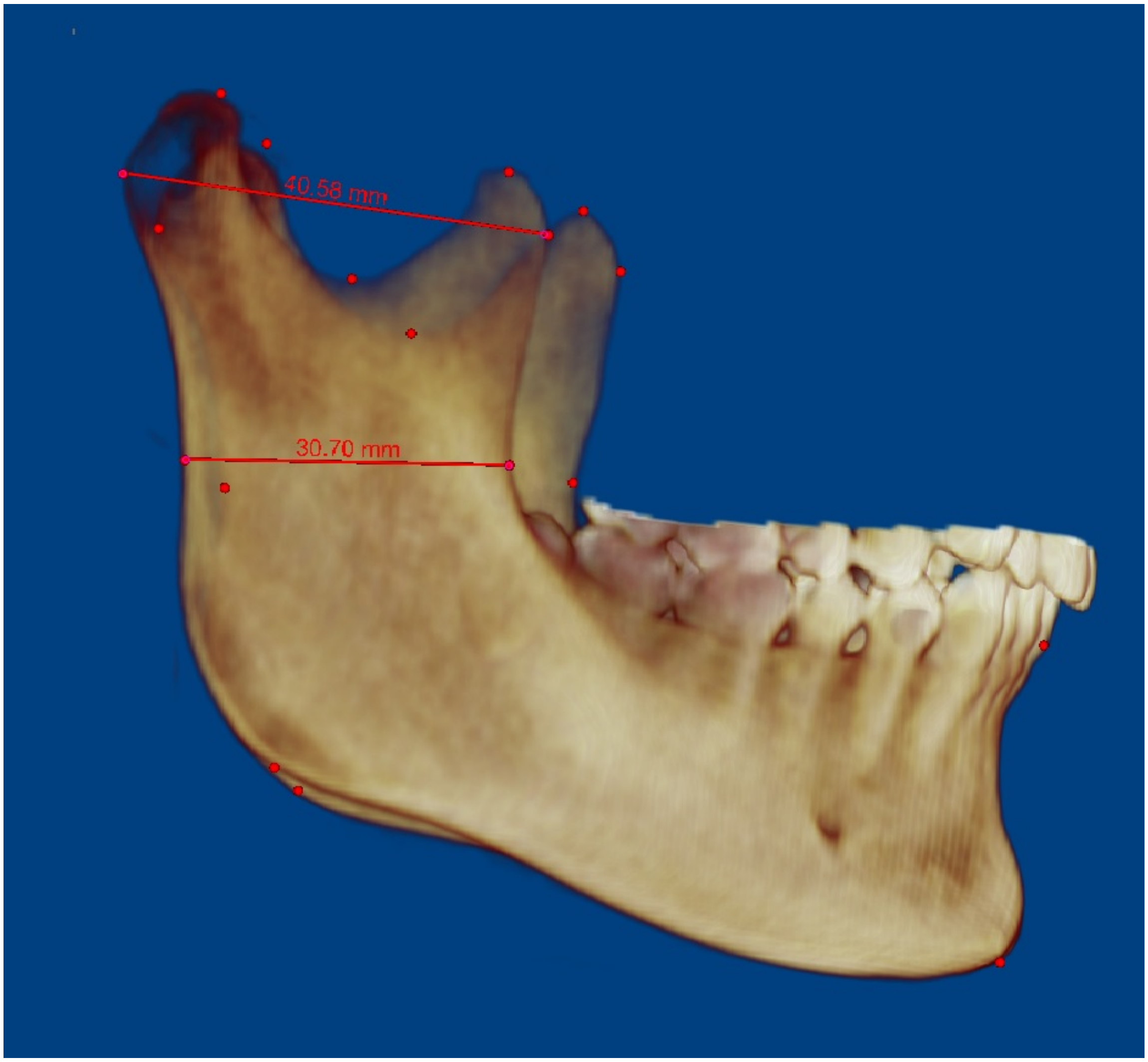


Figure 9. Three-Dimensional Maximum & Minimum Ramus Breadth

To measure the right maximum ramus breadth, a line was drawn from the landmark representing the posterior point of the mandibular condyle, to landmark representing the most protruded point on the anterior margin of the coronoid process. The software produced a linear millimeter measurement. The same measurement was done for the left side. (Figure 9)

The right minimum ramus breadth was measured by drawing a line from the landmark representing the most concave point of the anterior spine of the mandibular ramus, to the landmark representing the most concave point of the posterior edge of the ramus. The software produced a linear millimeter measurement. The same measurement was done for the left side. (Figure 9)

To measure anterior mandibular height, a line was drawn from the landmark representing the superior anterior alveolus to the landmark representing the inferior anterior alveolus. The software produced a linear millimeter measurement. (Figure 10)

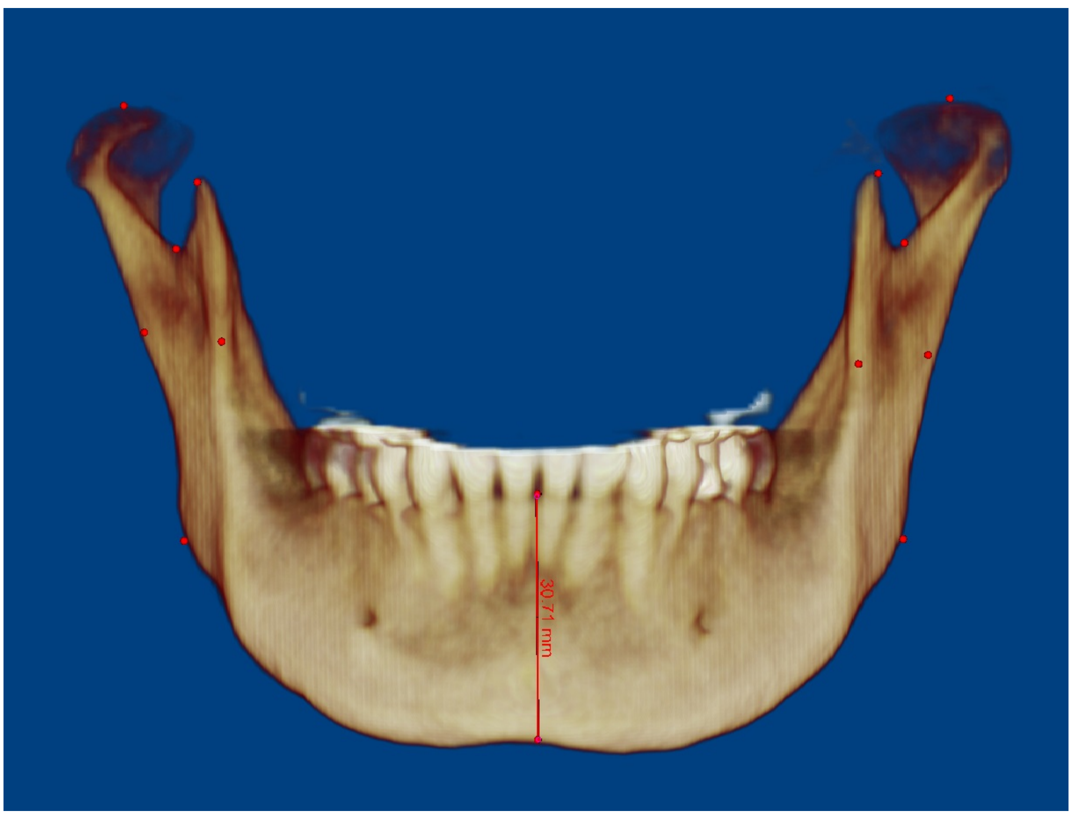


Figure 10. Three-Dimensional Anterior Mandibular Height

The skull was then oriented, looking axially down on the skull. A linear line was drawn down the length of the midline of the cranial base, and extended anteriorly. The mandible view only, was then restored. Right ramus convergence angle was measured by drawing a line extending from the landmark representing the posterior ramus to the landmark representing the anterior ramus, and extending it anteriorly until it intersected with the linear line representing the midline of the cranial base. An angular measurement was then made using a point on the midline cranial base line, the extension line of the right posterior to anterior ramus points, and the point of intersection of both lines. The software produced an angular measurement, representing the right ramus convergence angle. The same angular measurement was performed to find the left ramus convergence angle. (Figure 11)

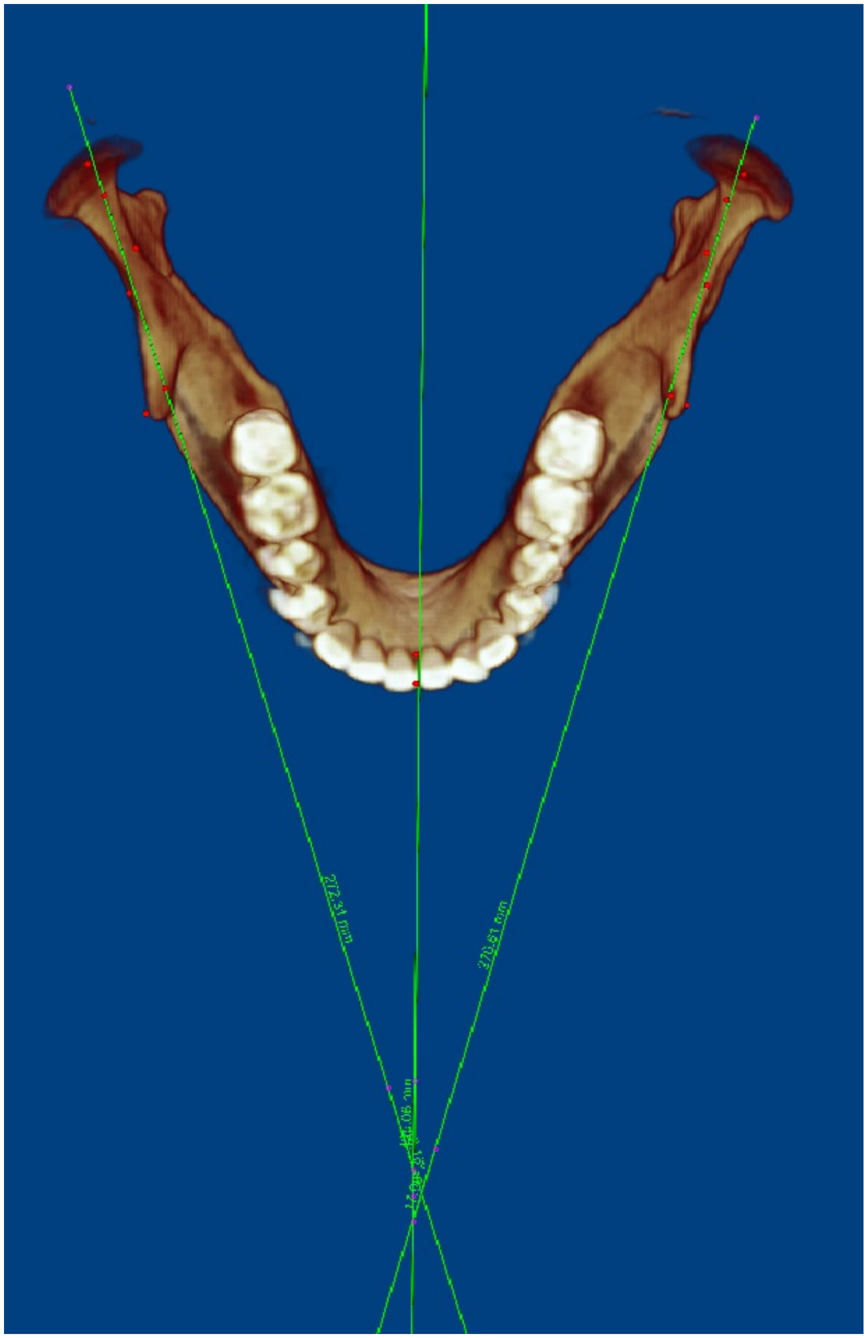


Figure 11. Three-Dimensional Convergence Angle of the Right & Left Ramus

To measure the mandibular base convergence angle, an angular measurement was made with the mandible in an axial view looking upwards onto the base of the mandible. An angular measurement was made from the landmark representing the right gonion, to the landmark representing the inferior anterior alveolus, to the landmark representing the left gonion. The software produced an angular measurement, representing the mandibular base convergence angle. (Figure 12)

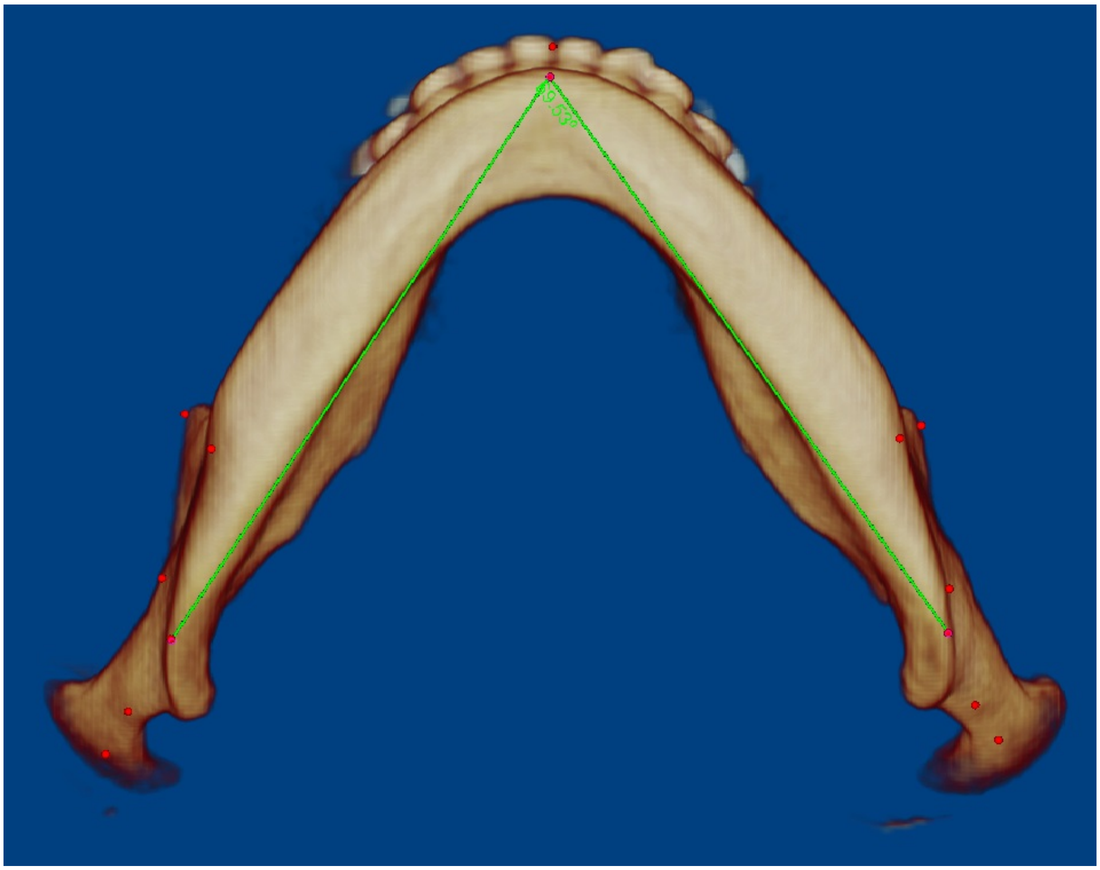


Figure 12. Three-Dimensional Convergence Angle of the Base of the Mandible

The two-dimensional cephalometric images, generated using orthogonal projection, were used to make a linear measurement of ramus height. This measurement was made utilizing a line between the two landmarks: condylion (Co) and gonion (Go) (Figure 13). The measurement up to 2 digits of a millimeter of 2D ramus height was compared with the average value of left and right ramus height measurements obtained from the three-dimensional CBCT image of that subject.

Table 4. List of Two-Dimensional Skeletal Landmarks

Landmarks	**Definition**
Condylion (Co)	(Most superior point on the head of the condyle)
Gonion (Go)	(Most inferior and posterior point along the angle of the mandible)

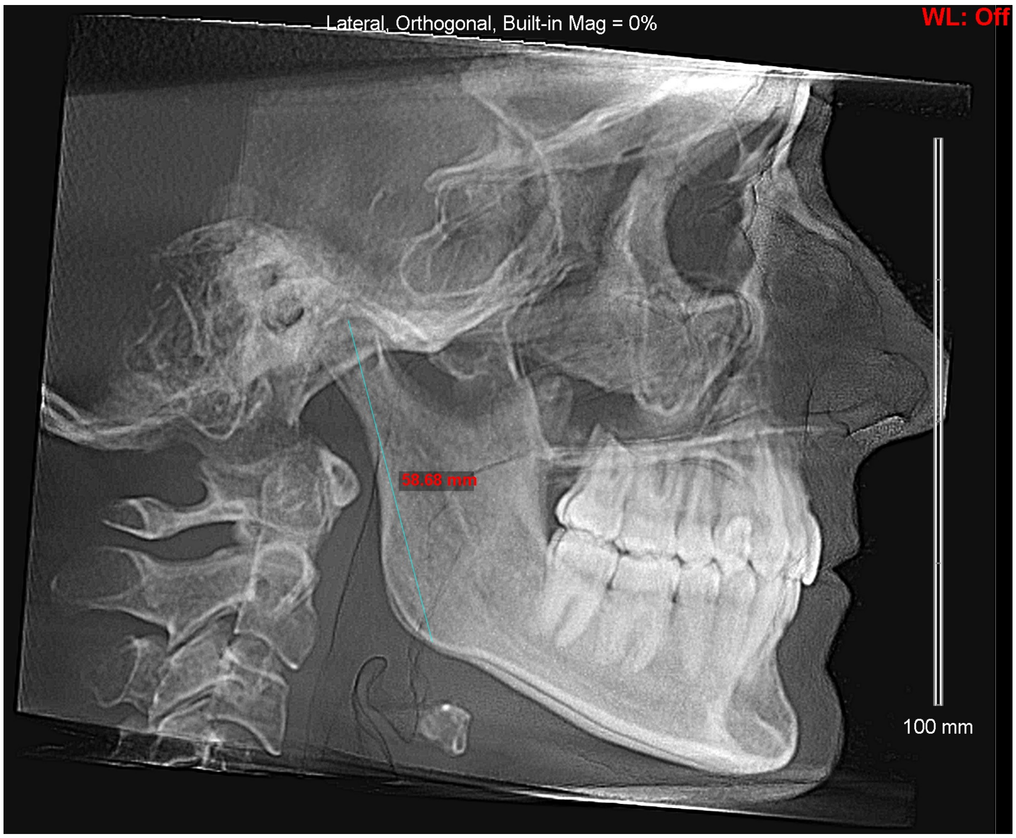


Figure 13. Two-Dimensional Ramus Height

3.4. <u>Statistical Analysis</u>

Analysis of the data was conducted by using IBM SPSS Statistics for Windows (version 22.0, Armonk, NY: IBM Corp).

The normal distribution of the data was tested using the Shapiro-Wilk test.

Analysis of variance (ANOVA) and Student's t-test were used to compare the mean vertical growth patterns of mandibles in all three vertical growth types, sex and race groups in Class I skeletal type, on the study variables. Paired t-test was used to evaluate the mean difference between 2D constructed ramus height, and the average values of actual ramus height from 3D images. Pearson correlations were estimated to investigate the association among the study variables in Class I skeletal types.

Analysis of variance (ANOVA) and Student's t-test were used to compare the mean vertical growth patterns of mandibles in all three vertical growth types in Class II and Class III skeletal types and sex on the study variables.

Statistical significance was set at 0.05.

4. RESULTS

4.1. Patient Demographics

A total of 445 CBCT images were reviewed; 331 subjects met the inclusion criteria and were analyzed for this study. The sample was divided into three antero-posterior skeletal classifications (Class I, Class II, Class III), into vertical growth classifications (hyperdivergent, normodivergent, and hypodivergent), and further divided by race and sex. The subject demographics were shown in Table 4.

Table 4. Patient Demographics

Class I			Class II			Class III			N
Hyperdivergent		**n**	**Hyperdivergent**		**n**	**Hyperdivergent**		**n**	
Caucasian	Male	6	Caucasian	Male	0	Caucasian	Male	2	8
	Female	14		Female	7		Female	2	23
Hispanic	Male	5	Hispanic	Male	1	Hispanic	Male	0	6
	Female	9		Female	4		Female	1	14
African-americ	Male	0	African-americ	Male	0	African-americ	Male	0	0
	Female	2		Female	1		Female	1	4
Others(Asian/N	Male	3	Others(Asian/N	Male	1	Others(Asian/N	Male	2	6
	Female	3		Female	1		Female	0	4
		42			15			8	
Normodivergent		**n**	**Normodivergent**		**n**	**Normodivergent**		**n**	
Caucasian	Male	14	Caucasian	Male	0	Caucasian	Male	5	19
	Female	44		Female	4		Female	8	56
Hispanic	Male	13	Hispanic	Male	3	Hispanic	Male	5	21
	Female	24		Female	6		Female	0	30
African-americ	Male	1	African-americ	Male	1	African-americ	Male	1	3
	Female	3		Female	2		Female	0	5
Others(Asian/N	Male	3	Others(Asian/N	Male	1	Others(Asian/N	Male	3	7
	Female	6		Female	0		Female	1	7
		108			17			23	
Hypodivergent		**n**	**Hypodivergent**		**n**	**Hypodivergent**		n	
Caucasian	Male	19	Caucasian	Male	1	Caucasian	Male	6	26
	Female	41		Female	5		Female	6	52
Hispanic	Male	5	Hispanic	Male	2	Hispanic	Male	3	10
	Female	8		Female	1		Female	4	13
African-americ	Male	1	African-americ	Male	0	African-americ	Male	2	3
	Female	2		Female	1		Female	0	3
Others(Asian/N	Male	5	Others(Asian/N	Male	1	Others(Asian/N	Male	0	6
	Female	4		Female	1		Female	0	5
		85			12			21	
		235			44			52	**331**

4.2. Intra- and Inter-reliability

Analysis of the data was conducted by using IBM SPSS Statistics for Windows (version 21.0, Armonk, NY: IBM Corp). To determine the intra-reliability measurements, one investigator assessed 11 images twice. To determine the inter-reliability measurements, each of the two investigators assessed 11 images once. The intra- and inter-class correlation coefficients were determined for each variable as an indicator of consistency on the study method for all of the variables measured. The correlation coefficient for all the study variables was higher than 0.90 (p-value<0.05), indicating a high degree of intra- and inter-reliability about the method used in this study.

4.3 Overall

The variables were normally distributed and tested with Shapiro-Wilk test.

Three-way ANOVA indicated that statistically significant differences were found only for sex, race and the three vertical growth pattern main factor and there was no interaction between these variables.

4.4. Mean Differences Among the Three Skeletal Types

Two-way ANOVA for Class I, II and III indicated that there were statistically significant mean differences only for the main factor, sex, for the following variables:

Ramus Height (R,L) and Anterior Mandibular Height, p-values< 0.001. The mean of male was higher than female.

One-way ANOVA indicated that there were statistically significant differences among the three skeletal classes only between Class I and III subjects, for the variable Ramus Height on both (R,L). The mean of the class III was higher than class I with p-values= 0.034 and 0.004, respectively.

4.5. Class I Subjects

Class I-overall analysis

One-way ANOVA in Class I skeletal type showed a statistically significant mean difference among the three levels of vertical growth patterns on the variables of Ramus Height (R,L), Anterior Mandibular Height, and Convergence Angle of the Base of Mandible, with p-values< 0.001. Post Hoc Bonferroni indicated statistically significant mean differences on the following variables:

Ramus Height (R,L) (mm)

The hypodivergent group differed significantly from the hyperdivergent and normodivergent groups, with p-values <0.001 to 0.005. The mean of the hypodivergent group was higher than the hyperdivergent and normodivergent groups.

Anterior Mandibular Height (mm)

The hypodivergent group differed significantly from the hyperdivergent and normodivergent groups, with p-values <0.009. The mean of the hypodivergent group was lower than hyperdivergent and normodivergent groups on Anterior Mandibular Height. The normodivergent group differed significantly from the hyperdivergent group, with p-value=0.004. The mean of the normodivergent group was lower than the hyperdivergent group.

Convergence Angle of the Base of Mandible (°)

The hypodivergent group differed significantly from the hyperdivergent and normodivergent groups, with p-values<0.001. The mean of hypodivergent group is lower than the hyperdivergent and normodivergent groups. The normodivergent group differed significantly from the hyperdivergent group, with p-value = 0.027. The mean of normodivergent was lower than hyperdivergent.

Minimum Ramus Breadth (R, L) (mm)

The hypodivergent group differed significantly from the hyperdivergent group. The means of hypodivergent are higher than the hyperdivergent group on Minimum Ramus Breadth for both R and L, p-values= 0.003 and 0.002, respectively.

Class I/ hyperdivergent group

Paired t-test between Ramus Height of 2D cephalometric projection (mm) and average of left and right Ramus Height (mm) indicated that there was no statistically significant mean difference, with p-value=0.923.

Statistically significant mean differences were found on the following variables:

Between Males and Females:

Ramus Height (R,L), Condylar Height (L), Coronoid Length (R,L), Convergence Angle of Ramus (L), Anterior Mandibular Height, Maximum Ramus Breadth (R, L), and Minimum Ramus Breadth (R,L), with p-values<0.034.

Between Caucasians and Hispanics:

Convergence Angle of Ramus (R,L), with p-values<0.04.

Pearson correlation indicated statistically significant correlation for the following variables:

- Ramus Height (R,L) correlated with Anterior Mandibular Height, r=(0.039; 0.499), with p-values <0.01.

- Convergence Angle of Ramus (R,L) correlated with Convergence Angle of the Base of Mandible, r=(0.036; 0.452) with p-values <0.019.

<u>Class I / Normodivergent group</u>

Paired t-test between Ramus Height of 2D Cephalometric projection (mm) and average of left and right Ramus Height (mm) indicated statistically significant mean difference with p-value=0.022.

Statistically significant mean differences were found on the following variables:

Between Males and Females:

Ramus Height (R,L), Coronoid Length (R), Anterior Mandibular Height, Maximum and Minimum Ramus Breadth (R,L), with p-values<0.031.

Between Caucasians and Hispanics:

Ramus Height (R,L), and Convergence Angle of Ramus (R,L), with p-values <0.05..

Pearson correlation indicated statistically significant correlation for the following variables:

- Ramus Height (R,L) correlated with Anterior Mandibular Height (mm), Maximum Ramus Breadth (R,L), and Minimum Ramus Breadth (R, L), r=(0.216; 0.744) with p-values <0.025.

- Convergence Angle of Ramus (R,L) correlated with Convergence Angle of the Base of Mandible, r=(0.200; 0.259) with p-values <0.038.

- Anterior Mandibular Height correlated with Ramus Height (R,L), Coronoid Length (R,L), Maximum Ramus Breadth (R,L), Minimum Ramus Breadth (R,L), r=(0.219,0.744), with p=values <0.023.

Class I / Hypodivergent group

Paired t-test between Ramus Height of 2D Cephalometric projection (mm) and average of left and right Ramus Height (mm) indicated statistically significant mean difference, p-value= 0.032.

Statistically significant mean differences were found on the following variables:

Between Males and Females:

Ramus Height (R,L), Condylar Height (L), Coronoid Length (R,L), Anterior Mandibular Height, Maximum Ramus Breadth (R,L) and Minimum Ramus Breadth (R,L), with p-values <0.032.

Between Caucasians and Hispanics:

Condylar Height (R,L), with p-values =0.014.

Pearson correlation indicated statistically significant correlation between the following variables:

- Ramus Height (R,L) correlated with Anterior Mandibular Height, Maximum Ramus Breadth (R,L), Minimum Ramus Breadth (R,L), r=(0.278;0.638), with p-values <0.010..

- Anterior Mandibular Height correlated with Ramus Height (R,L), Condylar Height (R, L), Coronoid Length (R,L), Maximum Ramus Breadth (R,L) and Minimum Ramus Breadth (R,L), r=(0.283;0.638), with p-values <0.009.

4.6. Class II Subjects

Class II-overall analysis

One-way ANOVA in Class II skeletal type showed a statistically significant mean difference among the three levels of vertical growth patterns on the variables Ramus Height (R,L), Condylar Height (R,L), Anterior Mandibular Height and Convergence Angle of the Base of Mandible, with p-values ranging from 0.020 to <0.001.

Post Hoc Bonferroni indicated statistically significant mean differences on the following variables:

Ramus Height (R,L)

Hyperdivergent group differed significantly from the hypodivergent and the normodivergent groups with p-values < 0.006. The mean of the hyperdivergent group was lower than the hypodivergent and normodivergent groups.

Condylar Height (R,L)

The hyperdivergent group differed significantly from the hypodivergent group, with p-values<0.018. The mean of the hyperdivergent group was lower than the hypodivergent group.

Anterior Mandibular Height (mm)

Hyperdivergent group differed significantly from hypodivergent and normodivergent groups with p-values=0.003. The mean of the hyperdivergent and the normodivergent groups were higher than hypodivergent group.

Convergence Angle of the Base of Mandible (°)

The hyperdivergent group differed significantly from the hypodivergent and normodivergent groups, with p-values<0.003. The mean of the hyperdivergent group was higher than the hypodivergent and normodivergent groups.
The normodivergent group differed significantly from the hyperdivergent group, with p-value= 0.002. The mean of the normodivergent was lower than the hyperdivergent group.

Paired t-test between Ramus Height of 2D Cephalometric projection (mm) and average of left and right Ramus Height (mm) indicated that there was no statistically significant mean difference for any of the vertical growth patterns in class II skeletal, with p-values=0.268, 0.426 and 0.403, for the hyperdivergent, normodivergent and hypodivergent groups, respectively.

Statistically significant mean differences were found on the following variables:

Class II/ Hyperdivergent group

Between Males and Females:

Ramus Height (R,L), with p-values <0.005.

Class II / Normodivergent group

Between Males and Females:

Ramus Height (R,L) and Coronoid Length (R,L), with p-values <0.011.

Class II / Hypodivergent group

Between Males and Females:

Ramus Height (R) and Minimum Ramus Breadth (L), with p-values <0.045.

4.7. Class III Subjects

Class III-overall analysis

One-way ANOVA in Class III skeletal type showed a non-statistically significant mean difference among the three levels of vertical growth patterns on the any of the study variables, p-value>0.05, except Minimum Ramus Breadth (L) with p-value=0.036. The mean of the hyperdivergent group is lower than the hypodivergent group, with p-value= 0.031.

Paired t-test between Ramus Height of 2D Cephalometric projection (mm) and average of left and right Ramus Height (mm) indicated that there was no statistically significant mean difference for any of the vertical growth patterns in Class III skeletal, with p-values=0.355, 0.343, and 0.295 for the hyperdivergent, normodivergent, and hypodivergent groups, respectively.

Statistically significant mean differences were found on the following variables:

Within Class III/ Hyperdivergent group

Between Males and Females:

Ramus Height (R,L) and Anterior Mandibular Height with p-values <0.038.

Within Class III / Normodivergent group

Between Males and Females:

Ramus Height (R,L), Coronoid Length (R,L), Convergence Angle of Ramus (L), Anterior Mandibular Height, Maximum Ramus Breadth (R,L) and Minimum Ramus Breadth (R,L), with p-values <0.046.

Within Class III / Hypodivergent group

Between Males and Females:

Ramus Height (R,L) and Anterior Mandibular Height, with p-values<0.002.

5. DISCUSSION

This study placed emphasis on the morphology of mandibles because the mandible was proven to be the strongest facial bone, after the skull and pelvic bone, for prediction of age and sex. (Poongodi et al., 2015) In addition, this study utilized CBCT imaging to make direct measurements on 3D mandibular structures to accurately identify landmarks, and thus produce more precise linear and angular measurements. According to Berco et al. (2009), CBCT imaging allows for clinically accurate and reliable three-dimensional linear measurements of craniofacial structures. The study also proved that skull orientation during the capturing of a three-dimensional CBCT image, does not affect the accuracy or the reliability of the linear measurements. CBCT imaging has the advantage of variations in head positioning, not resulting in changes of magnification or changes in the linear distances between reference landmarks that can affect the accuracy and reliability of the image, as seen with 2D imaging. (Berco et al., 2009)

There is a need to develop and test new 3D analyses for cephalometrics, as well as a need for data that can be used as reference values for 3D cephalometric measurements. (van Vlijmen et al., 2010) This study is an attempt at serving this purpose.

5.1. <u>Digitally Reconstructed Radiographs</u>

In order to generate 2D images from CBCT data, two projection methods have been utilized; orthogonal projection and perspective projection. Orthogonal projection sets a focus at an infinite distance from the plane of projection, mimicking parallel rays; and perspective projection sets a focus at a finite distance from the plane of projection, mimicking the geometry of conventional cephalometric radiographs. (Yang, Liu, & Gu, 2014)

A study by Lamichane et al. (2009), aimed to see if 2D images produced from 3D CBCT images could substitute for traditional cephalograms. It was hypothesized that 2D cephalograms generated with the perspective projection would have similar magnification to the traditional films, and thus be more accurate for comparing serial cephalograms and cephalometric norms, than the 2D images generated with the unmagnified orthogonal projection. The study confirmed that orthogonal projections represent the true anatomy better than perspective projections for linear measurements, and the linear measurements between identified landmarks were not statistically different from the actual phantom structure. (Lamichane et al., 2009)

Yang et al. (2014) investigated the consistency of linear measurements between orthogonally derived lateral cephalograms and conventional cephalograms, and investigated the influence of different magnifications on these comparisons. The results of the study showed that there was no statistically or clinically significant difference between measurements of traditional cephalograms and the orthogonally synthesized cephalograms. Linear measurements on both orthogonally derived lateral cephalograms and traditional lateral cephalograms were produced. (Yang et al., 2014)

Van Vlijmen et al. (2010), completed a study comparing orthogonal derived lateral cephalograms and traditional cephalograms utilizing 40 dry skulls. The study did find a statistically significant difference for 8 out of 10 angular measurements, but the actual mean difference ranged from -1.54° to 1.45°, which was similar to or smaller than the standard error for the repeated measurements. Van Vlijmen stressed that these differences did not have any clinical significance, and accepted that CBCT orthogonally synthesized cephalograms can replace traditional cephalograms in angular measurements. (van Vlijmen et al., 2010)

In our study, we utilized 2D images generated from the orthogonal projection of 3D CBCT images for classification of different vertical patterns, so the error from the magnification should be minimal.

5.2. <u>Sample Selection</u>

The sample of this study represents a normal cohort of the non-growing adult population seeking orthodontic treatment in the areas of the private practices that the CBCT images were obtained. The inclusion criteria were that the subjects' age must be more than 20 years old, and have a CVS stage V classification. We would like to ensure that the growth of mandible is complete, or at the receding stage. According to Love RJ et al in 1990, mandibular growth in males from 16 to 18 years was greater than that from 18 to 20 years implicating that the mandibular growth decreased after aged 20 years old. (Love, Murray, & Mamandras, 1990) The cervical vertebral maturation at stage V seemed to correspond to the decline of mandibular growth. (Ball, Woodside, Tompson, Hunter, & Posluns, 2011)

5.3. <u>Key Results</u>

In this study, ramus height was found to be longer in Class III subjects, than in Class I and II subjects (3.5- 4.5 mm); however, the significant difference was found only between Class III and Class I groups. This difference might be due to the antero-posterior overgrowth activity of Class III skeletal type. (Wolfe, Araujo, Behrents, & Buschang, 2011) In this study, we did not observe significant difference of ramus height between Class I and II. Jacob and Bushang observed significantly more growth in mandibular growth of Class I, than Class II division 1 adolescents. (Jacob & Buschang, 2014)

In this study, ramus height was found to be statistical significantly lower in the Class I hyperdivergent group, when compared to Class I normodivergent and Class I hypodivergent groups. Ramus height was found to be statistical significantly lower in the Class II hyperdivergent group, when compared to Class II normodivergent and Class II hypodivergent groups. There were no statistically significant differences found for ramus height, amongst the Class III subjects. Our study was the first to compare ramus height in all vertical growth patterns in all Class I, II and III patients. Mangla et al. (2011) compared Angle's Class I normodivergent molar controls with Angle's Class I or II molar hypodivergent and Angle's Class I or II molar hyperdivergent subjects. The ramus height was found to be significantly lower in the hyperdivergent group than the hypodivergent group. Our result was supported by the results of Mangla's study, although the previous study evaluated 2D lateral cephalograms and divided their vertical groups by Jarabak's ratio. Another study reported that high or low mandibular plane angle (MP-SN) was not accompanied by long or short anterior face height. The posterior facial height, determined by ramus height, was assumed to play a key role in the vertical facial height types. (Wang et al., 2013)

In this study, ramus height was found to be statistical significantly higher in males than in females for the all vertical growth patterns in Class I, Class II, and Class III subjects, representing antero-posterior skeletal classification and vertical growth patterns. In a study by Samatha et al (2016), panoramic radiographs were used to make linear measurements of the mandible. Mean measurements for males were greater than females, with height of the ramus showing the highest sexual dimorphism. In a study by Saini et al (2011), calipers were used to measure 116 dry skulls. The study concluded that ramus height dimensions were statistically higher in male subjects of a Northern Indian population. Indira et al (2012) evaluated the panoramic radiographs of 50 males and 50 females, showing that the linear measurements of the mandibular ramus were all higher for males, than in females. İlgüy et al (2014) evaluated pre-existing CBCT images in subjects of European decent, to provide data on mandibular measures of sexual dimorphism for data norms of identifying the sex of fragmentary skulls in forensics cases. The study proved that by utilizing 3D CBCT imaging, ramus height could be used to identify sex, with males having larger measurements than females, and that mandibular measurements on living persons may serve as a database that may contribute to sex identification. Dong et al (2015) utilized CBCT images to assess the accuracy of sex determination using mandibular measurements in a modern Chinese population, and evaluated the use of CBCT imaging to produce linear and angular measurements of the mandible. The study proved that significant sexual dimorphism could be found using linear measurements of the mandible, including maximum ramus height. All linear measurements in this study were higher in males than in females. A study by Inci et al (2016), utilized CT scans to demonstrate the accuracy of mandibular ramus morphometric analysis for sex identification in a Turkish population. Seven linear measurements, including maximum ramus vertical height, proved to be above 80% accuracy for sex determination, with males showing larger mean values than females. The results of ramus height measurements in this study, was in conjunction with the previous studies demonstrating that males have a significantly greater ramus height than females.

In this study, condylar height (left only), coronoid process length, anterior mandibular height, and maximum and minimum ramus breadth all showed mean measurements higher in males than females, in the three vertical growth patterns of Class I subjects. The study by Samatha et al in 2016 also showed statistical differences between the males and females for the measurements of maximum ramus breadth and condylar height, with males having larger mean values than females. (Samatha et al., 2016) Saini et al in 2011, found that linear measurements of the mandible were statistically significant between the sexes, with coronoid height and condylar height being higher for males than females. (Saini et al., 2011)

In this study, we utilized 3D CBCT images so we could compare convergence angles of ramus and base of mandibles. Our study was the first to report the comparison of convergence angles of the ramus and base of the mandibles. The angle parameter has a benefit over the linear parameter because it will not be influenced by the magnification error. The convergence angle of the base of the mandible was found to be higher in the hyperdivergent groups than in the normodivergent and hypodivergent groups in Class I and II subjects. This implicated that mandibular width in Class I and II hyperdivergent subjects was the highest, followed by normodivergent and hypodivergent groups; while there was no difference in Class III subjects. A study reported no statistically significant differences mandibular widths between Class II malocclusion and Class I malocclusion groups. (Lux, Conradt, Burden, & Komposch, 2003) A study reported mandibular base width in Class III malocclusion with low, average and high MP-SN angles. The study reported that the high-angle group was significantly smaller than those in the low-angle group. (Chen, Terada, Wu, & Saito, 2007) Our study did not observe any difference among groups in Class III subjects. The reason might be due the difference in age of the subjects. The subjects in our study were non-growers, aged more than 20 years old; while the subjects in Chen et al study, were growers aged 10-14 years old. Chen F et al reported that no statistically significant differences of mandibular width were found between Class I and Class III malocclusion groups. (Chen, Terada, Yang, & Saito, 2008) Recently, Akan et al reported that subjects aged 14-16 years old with Class III malocclusion had significantly wider mandibular base width than pseudoclass III subjects. (Akan & Veli, 2017)

Also in this study, there was no difference in the convergence angle of the base of the mandible, between male and female sexes, within each skeletal category. Dong et al proved a similar finding in 2015. Dong et al (2015) measured the mental angle (an angle between the right and left gonion, and midline of mandible), which is implicated as mandibular width, but not exactly the same as the convergence angle of the base of the mandible, in this study. The mental angle in the study by

Dong, showed no statistically significant difference in the male and female subjects of the Han Chinese population. Rohila evaluated masseter muscle thickness and the mandibular width in different vertical growth patterns. The study reported that there was no correlation between mandibular width and thickness of the masseter muscle, but negatively correlation between masseter muscle thickness and vertical growth pattern. (Rohila, Sharma, Shrivastav, Nagar, & Singh, 2012)

Anterior mandibular height was found to be statistically different in Class I and Class II subjects. The mean of the anterior mandibular height in the hyperdivergent groups were higher than the normodivergent and hypodivergent groups.

In this study, condylar height was found to be statistically different in Class II subjects. They mean of the condylar height in the Class II hyperdivergent group was lower than the mean of the hypodivergent group.

The test between the ramus height of the 2D cephalometric orthogonal projection and average of the 3D right and left ramus heights, found that majority of the results did not show any difference except Class I normodivergent and hypodivergent; however the mean differences were 0.27-0.45 mm and 0.33-0.44 mm respectively, and were clinically insignificant. A study by van Vlijmen showed that there were statistically significant differences in locating most landmarks on conventional cephalometric radiographs compared with the 3D model. (2010)

This study also showed a statistically significant difference between Caucasian and Hispanic subjects in all three vertical growth patterns of the Class I skeletal relationship, for the variables of convergence angle of the ramus (R,L), and minimum ramus breadth (R). The convergence angles of the ramus showed higher means in Caucasians, than Hispanics. The right minimum ramus breadth showed higher mean values for Hispanics, than Caucasians. Using submento-vertex view of 2D extraoral radiographs of subjects 19 years old or older, to compare the mandibular dental arch among American Hispanics, Blacks and Whites; the study reported that Hispanics had widest mandibular dental arch, followed by Blacks and Whites respectively. (Nummikoski et al., 1988) Note that this study investigated the mandibular dental arches, and not the skeletal body of mandibles.

In this study, we performed Pearson correlation on Class I antero-posterior skeletal types to evaluate the correlation of the parameters of the mandibles, to the three patterns of vertical growth. There was a good positive correlation in many of the studied parameters in the Class I normodivergent group with the vertical anterior and posterior parameters, as well as the angular parameters. The Class I hypodivergent group, seemed to have no good correlation of angular parameters, which we speculate the poor correlation is due to less tone of the attached masticatory muscles. (Rohila et al., 2012)

5.4. <u>Clinical Significance</u>

There is clinical significance for orthodontic mechanics and growth prediction, especially when comparing various data measurements to normative values. (Mangla et al., 2011)

CBCT is becoming a useful tool to analyze malocclusions and to evaluate the effects of orthodontic, orthopedic, and surgical interventions and treatment. The images produced by CBCT 3D technology, allow the assessment and evaluation of the craniofacial skeleton in life size dimensions without distortion and overlapping anatomical structures. (Yang et al., 2014)

There have been past longitudinal studies using longitudinal 2D cephalometric records, computing linear and angular values at various time intervals. These studies have allowed orthodontists to further understand craniofacial skeletal growth patterns, which is valuable for the proper diagnosis and treatment of skeletal malocclusions. (Yang et al., 2014) Likewise, three-dimensional measurements on the same patient can be used before and after treatment, to quantify the changes seen due to the effects of treatment, as well as growth. (van Vlijmen et al., 2010)

Three-dimensional studies prove to have some clinical significance for orthognathic surgical treatment, as well as finding the side of the problem in asymmetrical and hemifacial patients. There was a study on the relationship between mandibular ramus height and muscle function in asymmetrical hemifacial microsomia patients, by Suzuki et al. Electromyography (EMG) values of the masseter and temporal muscles, the occlusal status, and the amount of mandibular lateral deviation at maximum opening were measured along with the affected and unaffected mandibular ramii. The study showed that as the height of the mandibular ramus on the affected decreased, the EMG value of the masseter muscle on that affected side also decreased. There was no statistical difference in occlusal function amongst the asymmetrical groups and the controls. (Suzuki et al., 2017)

CBCT studies have also been useful for studies focusing on orthognathic surgical treatment. CBCT imaging can be used to assess mandibular morphology, such as the ramus for a case being planned for a mandibular ramus osteotomy surgery. Utilizing 3D CBCT radiographs and technology, measurements can be compared between deviated and contralateral sides to allow for proper surgical treatment planning. (Inoue et al., 2015)

Sexual dimorphism is expressed in most human bones. The mandible is usually well preserved and used for sex and race determination in forensic and archaeological cases. Sexual dimorphic characteristics of the mandible have been reported. CBT imagining can be used to investigate the potential use of the mandible for sex and race determination. (Dong et al., 2015)

5.5. Strengths

- This study utilizes 3D CBCT imaging, and actual measurements from these images.
- This study has larger number of samples in Class I, Class II, and Class III
- This study is the first study to categorize the samples into all three antero-posterior classifications, as well as subcategorizing the samples into the three vertical growth patterns, sex and race (Class I only)
- This is the first study to report convergence angles of the ramus and the base of the mandible.

5.6. Limitations

- This study was based on patients selected from the limited demographics of three private orthodontic practices in Illinois and Colorado. The ethnic backgrounds found in this study represent mostly Caucasian and Hispanic populations, which could not represent the general population.
- The Class II samples in this study were not subclassified into Class II div 1 or 2. We used the ANB angle to categorize Class I, Class II, and Class III antero-posterior skeletal types.
- There were only limited numbers of Class II and Class III skeletal types in this study, so race could not be analyzed in these groups.

5.7. Future Research

- Future studies may include a larger sample size for each skeletal category, as well as from each race. This would allow for more data contributing to normative values for the various races. A higher population sample will also contribute to more accurate sexual dimorphism data.
- A study comparing the difference of the 2D ramus height and average of the 3D ramus height, in perspective projection may be useful to show the differences that magnification errors make on linear measurements
- Future studies may evaluate volumetric studies of the mandibular structures, including all three antero-posterior classifications and the three vertical growth patterns.

6. CONCLUSION

The results of this study are the first to demonstrate the difference in the linear and angular measurements of the mandible in hyperdivergent, normodivergent, and hypodivergent samples in Class I, Class II, and Class III skeletal types, using 3D CBCT images. There were significant differences in several variables in the hyperdivergent, normodivergent, and hypodivergent samples of the Class I and Class II, but not Class III skeletal types.

This study also showed that there was a statistically significant difference for ramus height between male and female subjects for all skeletal types. Thus, ramus height can be used as an indicator for sex differentiation.

The study provided a preliminary result to create a norm for 3D cephalometric radiographs.

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APPENDIX

STUDY CERTIFICATION

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Approval Notice
Initial Review – Expedited Review

April 27, 2017

Peyton Harris, DDS
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Phone: (678) 779-0202 / Fax: (312) 996-0863

RE: Protocol # 2017-0467
"Evaluation of Vertical Components of the Mandible using Three-Dimensional Radiographs"

Please note that in order for this research to qualify for an exemption, the data must be recorded in such a manner that subjects cannot be directly or indirectly identified. The data, however, will be coded, not de-identified. As a result, your research was reviewed by members of IRB #3 via expedited IRB review procedures.

UIC IRB #3 is not the Privacy Board for Dr. Bradford N. Edgren's Private Practice (Greeley, CO), Dr. Terry Selke's Private Office (Grayslake, IL), or Dr. Ronald Jacobson's Private Office (Chicago, IL). Please be reminded that each of these covered entities must address their own HIPAA requirements.

Dear Dr. Harris:

Members of Institutional Review Board (IRB) #3 reviewed and approved your research protocol under expedited review procedures [45 CFR 46.110(b)(1)] on April 27, 2017. You may now begin your research.

Overall

One-way/ Descriptive

		N	Mean	Std. Deviation	Std. Error
Ramus Height (R) (mm)	Skeletal Class I	108	64.0861	5.80455	.55854
	Skeletal Class II	16	63.9813	4.78375	1.19594
	Skeletal Class III	23	67.5739*	7.01610	1.46296
	Total	147	64.6204	6.00762	.49550
Ramus Height (L) (mm)	Skeletal Class I	108	63.3093	6.08249	.58529
	Skeletal Class II	16	63.6688	4.87808	1.21952
	Skeletal Class III	23	67.8174*	6.11300	1.27465
	Total	147	64.0537	6.15203	.50741
Anterior Mandibular Height (mm)	Skeletal Class I	108	32.0306	3.16468	.30452
	Skeletal Class II	16	33.5063	3.22273	.80568
	Skeletal Class III	23	32.4870	2.99018	.62350
	Total	147	32.2626	3.15777	.26045
Convergence Angle of the Base of Mandible (°)	Skeletal Class I	108	69.1417	5.00118	.48124
	Skeletal Class II	16	66.4250	5.77552	1.44388
	Skeletal Class III	23	69.3261	5.59766	1.16719
	Total	147	68.8748	5.21743	.43033

Descriptive Statistics/
Dependent Variable: Ramus Height (R) (mm)

Group Skeletal Classification	Sex	Mean	Std. Deviation	N
Skeletal Class I	MALE	70.0032	4.49848	31
	FEMALE	61.7039	4.40647	77
	Total	64.0861	5.80455	108
Skeletal Class II	MALE	69.2750	4.22009	4
	FEMALE	62.2167	3.57233	12
	Total	63.9813	4.78375	16
Skeletal Class III	MALE	70.7143	5.95894	14
	FEMALE	62.6889	5.79341	9
	Total	67.5739	7.01610	23
Total	MALE	70.1469*	4.85267	49
	FEMALE	61.8571	4.41898	98
	Total	64.6204	6.00762	147

Descriptive Statistics/
Dependent Variable: Ramus Height (L) (mm)

Group Skeletal Classification	Sex	Mean	Std. Deviation	N
Skeletal Class I	MALE	69.3645	4.78495	31
	FEMALE	60.8714	4.69815	77
	Total	63.3093	6.08249	108
Skeletal Class II	MALE	69.2250	4.80651	4
	FEMALE	61.8167	3.34361	12
	Total	63.6688	4.87808	16
Skeletal Class III	MALE	70.5357	4.63840	14
	FEMALE	63.5889	5.89543	9
	Total	67.8174	6.11300	23
Total	MALE	69.6878*	4.67714	49
	FEMALE	61.2367	4.69991	98
	Total	64.0537	6.15203	147

Descriptive Statistics/
Dependent Variable: Anterior Mandibular Height (mm)

Group Skeletal Classification	Sex	Mean	Std. Deviation	N
Skeletal Class I	MALE	35.0710	2.08697	31
	FEMALE	30.8065	2.66317	77
	Total	32.0306	3.16468	108
Skeletal Class II	MALE	35.7500	3.23986	4
	FEMALE	32.7583	2.97641	12
	Total	33.5063	3.22273	16
Skeletal Class III	MALE	33.9429	2.26026	14
	FEMALE	30.2222	2.60901	9
	Total	32.4870	2.99018	23
Total	MALE	34.8041*	2.25804	49
	FEMALE	30.9918	2.75523	98
	Total	32.2626	3.15777	147

Class I Ramus Height (mm) (R)

Dependent Variable: Ramus Height (R) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	CAUCASIAN	66.8667	5.47272	6
		HISPANIC	64.0800	2.63192	5
		Total	65.6000*	4.45690	11
	FEMALE	CAUCASIAN	59.8429	3.08837	14
		HISPANIC	59.7556	4.10674	9
		Total	59.8087	3.43086	23
	Total	CAUCASIAN	61.9500	5.03122	20
		HISPANIC	61.3000	4.13931	14
		Total	61.6824	4.62919	34
Normodivergent	MALE	CAUCASIAN	68.3071	4.26298	14
		HISPANIC	71.4692	4.74629	13
		Total	69.8296*	4.69851	27
	FEMALE	CAUCASIAN	61.2455	4.43057	44
		HISPANIC	63.1458	4.05001	24
		Total	61.9162	4.36648	68
	Total	CAUCASIAN	62.9500	5.31460	58
		HISPANIC	66.0703*	5.84945	37
		Total	64.1653	5.70710	95
Hypodivergent	MALE	CAUCASIAN	73.6632	6.12683	19
		HISPANIC	72.6400	4.49533	5
		Total	73.4500*	5.75084	24
	FEMALE	CAUCASIAN	63.3098	3.99842	41
		HISPANIC	61.8875	5.03089	8
		Total	63.0776	4.15884	49
	Total	CAUCASIAN	66.5883	6.77345	60
		HISPANIC	66.0231	7.15159	13
		Total	66.4877*	6.79467	73
Total	MALE	CAUCASIAN	70.6949	6.06291	39
		HISPANIC	70.1174	5.29448	23
		Total	70.4806	5.75220	62
	FEMALE	CAUCASIAN	61.9020	4.24644	99
		HISPANIC	62.1561	4.37407	41
		Total	61.9764	4.26997	140
	Total	CAUCASIAN	64.3870	6.23571	138
		HISPANIC	65.0172	6.06302	64
		Total	64.5866	6.17344	202

Class II Ramus Height (mm) (R)

Dependent Variable: Ramus Height (R) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	63.5000	.	1
		Asian	72.8000	.	1
		Total	68.1500*	6.57609	2
	FEMALE	Caucasian	58.7143	2.87021	7
		Hispanic	53.7250	5.56739	4
		Black	54.7000	.	1
		Asian	53.5000	.	1
		Total	56.4692	4.27948	13
	Total	Caucasian	58.7143	2.87021	7
		Hispanic	55.6800	6.50823	5
		Black	54.7000	.	1
		Asian	63.1500	13.64716	2
		Total	58.0267*	5.97321	15
Normodivergent	MALE	Hispanic	67.2333	1.30512	3
		Black	75.4000	.	1
		Asian	68.1000	.	1
		Total	69.0400*	3.69229	5
	FEMALE	Caucasian	64.6500	2.29274	4
		Hispanic	61.6500	3.95209	6
		Black	59.0500	.91924	2
		Total	62.2167	3.57233	12
	Total	Caucasian	64.6500	2.29274	4
		Hispanic	63.5111	4.24041	9
		Black	64.5000	9.46203	3
		Asian	68.1000	.	1
		Total	64.2235	4.73834	17
Hypodivergent	MALE	Caucasian	68.5000	.	1
		Hispanic	69.5500	4.73762	2
		Asian	71.6000	.	1
		Total	69.8000*	3.02765	4
	FEMALE	Caucasian	60.7400	4.71148	5
		Hispanic	66.6000	.	1
		Black	66.8000	.	1
		Asian	65.6000	.	1
		Total	62.8375	4.60246	8
	Total	Caucasian	62.0333	5.27206	6
		Hispanic	68.5667	3.75810	3
		Black	66.8000	.	1
		Asian	68.6000	4.24264	2
		Total	65.1583	5.26609	12
Total	MALE	Caucasian	68.5000	.	1
		Hispanic	67.3833	3.17453	6
		Black	75.4000	.	1
		Asian	70.8333	2.44199	3
		Total	69.1545	3.59204	11

	FEMALE	Caucasian	60.8313	4.03100	16
		Hispanic	59.2182	6.17864	11
		Black	59.9000	5.06425	4
		Asian	59.5500	8.55599	2
		Total	60.1030	4.97968	33
	Total	Caucasian	61.2824	4.32352	17
		Hispanic	62.1000	6.57162	17
		Black	63.0000	8.20274	5
		Asian	66.3200	7.71213	5
		Total	62.3659	6.09700	44

Class III Ramus Height (mm) (R)

Dependent Variable: Ramus Height (R) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	70.9500	7.84889	2
		Asian	73.2000	2.12132	2
		Total	72.0750*	4.87057	4
	FEMALE	Caucasian	56.3000	3.39411	2
		Hispanic	56.6000	.	1
		Black	60.4000	.	1
		Total	57.4000	2.80357	4
	Total	Caucasian	63.6250	9.79366	4
		Hispanic	56.6000	.	1
		Black	60.4000	.	1
		Asian	73.2000	2.12132	2
		Total	64.7375	8.66404	8
Normodivergent	MALE	Caucasian	73.1600	3.53030	5
		Hispanic	68.8600	7.64186	5
		Black	65.0000	.	1
		Asian	71.0500	9.68736	2
		Middle Eastern/India	72.8000	.	1
		Total	70.7143*	5.95894	14
	FEMALE	Caucasian	62.7625	6.18892	8
		Middle Eastern/India	62.1000	.	1
		Total	62.6889	5.79341	9
	Total	Caucasian	66.7615	7.36326	13
		Hispanic	68.8600	7.64186	5
		Black	65.0000	.	1
		Asian	71.0500	9.68736	2
		Middle Eastern/India	67.4500	7.56604	2
		Total	67.5739	7.01610	23
Hypodivergent	MALE	Caucasian	74.5000	3.63318	4
		Hispanic	71.0200	7.95217	5
		Black	69.4000	.70711	2
		Total	71.9909*	5.79973	11
	FEMALE	Caucasian	61.7286	5.55209	7
		Hispanic	65.2667	2.19621	3
		Total	62.7900	4.95411	10
	Total	Caucasian	66.3727	7.99839	11
		Hispanic	68.8625	6.81027	8
		Black	69.4000	.70711	2
		Total	67.6095	7.07354	21
Total	MALE	Caucasian	73.2455	4.09789	11
		Hispanic	69.9400	7.44016	10
		Black	67.9333	2.58908	3
		Asian	72.1250	5.85854	4
		Middle Eastern/India	72.8000	.	1
		Total	71.3862	5.61056	29
	FEMALE	Caucasian	61.5765	5.76460	17
		Hispanic	63.1000	4.68971	4

		Black	60.4000	.	1
		Middle Eastern/India	62.1000	.	1
		Total	61.8130	5.25412	23
	Total	Caucasian	66.1607	7.71964	28
		Hispanic	67.9857	7.32675	14
		Black	66.0500	4.31934	4
		Asian	72.1250	5.85854	4
		Middle Eastern/India	67.4500	7.56604	2
		Total	67.1519*	7.22774	52

Class I Ramus Height (mm) (L)

Dependent Variable: Ramus Height (L) (mm)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	66.1167	4.45664	6
		FEMALE	59.2214	5.16246	14
		Total	61.2900	5.82851	20
	HISPANIC	MALE	63.9000	4.20535	5
		FEMALE	60.0556	6.35415	9
		Total	61.4286	5.82599	14
	Total	MALE	65.1091*	4.28310	11
		FEMALE	59.5478	5.53204	23
		Total	61.3471	5.73893	34
Normodivergent	CAUCASIAN	MALE	69.0857	5.08964	14
		FEMALE	60.2955	4.37604	44
		Total	62.4172	5.89505	58
	HISPANIC	MALE	69.0231	4.57478	13
		FEMALE	62.5917	5.14223	24
		Total	64.8514*	5.79299	37
	Total	MALE	69.0556*	4.75527	27
		FEMALE	61.1059	4.75284	68
		Total	63.3653	5.94549	95
Hypodivergent	CAUCASIAN	MALE	73.5105	7.06454	19
		FEMALE	63.0073	4.35823	41
		Total	66.3333	7.23737	60
	HISPANIC	MALE	72.9800	4.35741	5
		FEMALE	61.6125	5.90071	8
		Total	65.9846	7.73130	13
	Total	MALE	73.4000*	6.51220	24
		FEMALE	62.7796	4.60190	49
		Total	66.2712*	7.27340	73
Total	CAUCASIAN	MALE	70.7846	6.58293	39
		FEMALE	61.2667	4.68820	99
		Total	63.9565	6.80021	138
	HISPANIC	MALE	68.7696	5.24781	23
		FEMALE	61.8439	5.51711	41
		Total	64.3328	6.33727	64
	Total	MALE	70.0371	6.15556	62
		FEMALE	61.4357	4.93203	140
		Total	64.0757	6.64360	202

Class II Ramus Height (mm) (L)

Dependent Variable: Ramus Height (L) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	65.1000	.	1
		Asian	70.9000	.	1
		Total	68.0000*	4.10122	2
	FEMALE	Caucasian	57.1571	3.16957	7
		Hispanic	52.4500	4.17493	4
		Black	55.8000	.	1
		Asian	52.4000	.	1
		Total	55.2385	3.84936	13
	Total	Caucasian	57.1571	3.16957	7
		Hispanic	54.9800	6.71394	5
		Black	55.8000	.	1
		Asian	61.6500	13.08148	2
		Total	56.9400*	5.83656	15
Normodivergent	MALE	Hispanic	67.2667	3.41223	3
		Black	75.1000	.	1
		Asian	70.5000	.	1
		Total	69.4800*	4.20143	5
	FEMALE	Caucasian	62.6500	3.93658	4
		Hispanic	61.3333	3.64509	6
		Black	61.6000	2.40416	2
		Total	61.8167	3.34361	12
	Total	Caucasian	62.6500	3.93658	4
		Hispanic	63.3111	4.47394	9
		Black	66.1000	7.97747	3
		Asian	70.5000	.	1
		Total	64.0706	5.00534	17
Hypodivergent	MALE	Caucasian	68.1000	.	1
		Hispanic	66.3500	6.85894	2
		Asian	70.5000	.	1
		Total	67.8250	4.42069	4
	FEMALE	Caucasian	60.0800	4.62839	5
		Hispanic	68.5000	.	1
		Black	67.5000	.	1
		Asian	62.9000	.	1
		Total	62.4125	5.01524	8
	Total	Caucasian	61.4167	5.27804	6
		Hispanic	67.0667	5.00633	3
		Black	67.5000	.	1
		Asian	66.7000	5.37401	2
		Total	64.2167	5.33272	12
Total	MALE	Caucasian	68.1000	.	1
		Hispanic	66.6000	3.84812	6
		Black	75.1000	.	1
		Asian	70.6333	.23094	3
		Total	68.6091	3.91215	11

	FEMALE	Caucasian	59.4438	4.25989	16
		Hispanic	58.7545	6.42330	11
		Black	61.6250	4.97418	4
		Asian	57.6500	7.42462	2
		Total	59.3697	5.13764	33
	Total	Caucasian	59.9529	4.62819	17
		Hispanic	61.5235	6.73420	17
		Black	64.3200	7.40756	5
		Asian	65.4400	8.02359	5
		Total	61.6795	6.29132	44

Class III Ramus Height (mm) (L)

Dependent Variable: Ramus Height (L) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	72.7000	6.78823	2
		Asian	66.8000	11.73797	2
		Total	69.7500*	8.53756	4
	FEMALE	Caucasian	51.6000	2.12132	2
		Hispanic	56.8000	.	1
		Black	61.9000	.	1
		Total	55.4750	5.08486	4
	Total	Caucasian	62.1500	12.85548	4
		Hispanic	56.8000	.	1
		Black	61.9000	.	1
		Asian	66.8000	11.73797	2
		Total	62.6125	10.02703	8
Normodivergent	MALE	Caucasian	72.2200	2.74627	5
		Hispanic	69.3800	5.31291	5
		Black	64.1000	.	1
		Asian	70.6500	7.84889	2
		Middle Eastern/India	74.1000	.	1
		Total	70.5357*	4.63840	14
	FEMALE	Caucasian	64.0500	6.12652	8
		Middle Eastern/India	59.9000	.	1
		Total	63.5889	5.89543	9
	Total	Caucasian	67.1923	6.44392	13
		Hispanic	69.3800	5.31291	5
		Black	64.1000	.	1
		Asian	70.6500	7.84889	2
		Middle Eastern/India	67.0000	10.04092	2
		Total	67.8174	6.11300	23
Hypodivergent	MALE	Caucasian	74.6750	5.86423	4
		Hispanic	71.0600	7.79667	5
		Black	70.4000	1.83848	2
		Total	72.2545*	6.22212	11
	FEMALE	Caucasian	61.8143	4.50608	7
		Hispanic	63.5000	4.22256	3
		Total	62.3200	4.26166	10
	Total	Caucasian	66.4909	8.03747	11
		Hispanic	68.2250	7.42558	8
		Black	70.4000	1.83848	2
		Total	67.5238	7.30609	21
Total	MALE	Caucasian	73.2000	4.39795	11
		Hispanic	70.2200	6.35187	10
		Black	68.3000	3.86264	3
		Asian	68.7250	8.45000	4
		Middle Eastern/India	74.1000	.	1
		Total	71.0793	5.70685	29
	FEMALE	Caucasian	61.6647	6.31139	17

		Hispanic	61.8250	4.80720	4
		Black	61.9000	.	1
		Middle Eastern/India	59.9000	.	1
		Total	61.6261	5.68053	23
	Total	Caucasian	66.1964	7.98014	28
		Hispanic	67.8214	6.98242	14
		Black	66.7000	4.49296	4
		Asian	68.7250	8.45000	4
		Middle Eastern/India	67.0000	10.04092	2
		Total	66.8981*	7.36722	52

Class I Condylar Height (mm) (R)

Dependent Variable: Condylar Height (R) (mm)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	20.1000	4.00300	6
		FEMALE	19.6143	3.43530	14
		Total	19.7600	3.51334	20
	HISPANIC	MALE	20.5000	2.92147	5
		FEMALE	19.8111	1.64730	9
		Total	20.0571	2.10081	14
	Total	MALE	20.2818	3.38669	11
		FEMALE	19.6913	2.82310	23
		Total	19.8824	2.97784	34
Normodivergent	CAUCASIAN	MALE	19.5429	2.94768	14
		FEMALE	20.0727	2.50825	44
		Total	19.9448	2.60385	58
	HISPANIC	MALE	20.8385	2.75274	13
		FEMALE	20.7458	2.75712	24
		Total	20.7784	2.71745	37
	Total	MALE	20.1667	2.87696	27
		FEMALE	20.3103	2.59852	68
		Total	20.2695	2.66578	95
Hypodivergent	CAUCASIAN	MALE	21.5263	2.21506	19
		FEMALE	20.4122	2.83268	41
		Total	20.7650	2.68516	60
	HISPANIC	MALE	24.0000	4.09939	5
		FEMALE	20.4250	4.84937	8
		Total	21.8000*	4.75360	13
	Total	MALE	22.0417	2.79564	24
		FEMALE	20.4143	3.18061	49
		Total	20.9493	3.13582	73
Total	CAUCASIAN	MALE	20.5949	2.87841	39
		FEMALE	20.1485	2.77012	99
		Total	20.2746	2.79784	138
	HISPANIC	MALE	21.4522	3.26258	23
		FEMALE	20.4780	3.02866	41
		Total	20.8281	3.12458	64
	Total	MALE	20.9129	3.02896	62
		FEMALE	20.2450	2.84120	140
		Total	20.4500	2.90897	202

Class II Condylar Height (mm) (R)

Descriptive Statistics
Dependent Variable: Condylar Height (R) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	17.4000	.	1
		Asian	23.5000	.	1
		Total	20.4500	4.31335	2
	FEMALE	Caucasian	18.5857	.54903	7
		Hispanic	17.4500	3.99208	4
		Black	15.9000	.	1
		Asian	17.0000	.	1
		Total	17.9077	2.20849	13
	Total	Caucasian	18.5857	.54903	7
		Hispanic	17.4400	3.45731	5
		Black	15.9000	.	1
		Asian	20.2500	4.59619	2
		Total	18.2467*	2.51193	15
Normodivergent	MALE	Hispanic	19.1333	1.58219	3
		Black	21.1000	.	1
		Asian	17.2000	.	1
		Total	19.1400	1.77567	5
	FEMALE	Caucasian	20.7500	3.75278	4
		Hispanic	20.1000	2.68104	6
		Black	18.3500	2.05061	2
		Total	20.0250	2.86265	12
	Total	Caucasian	20.7500	3.75278	4
		Hispanic	19.7778	2.31343	9
		Black	19.2667	2.15019	3
		Asian	17.2000	.	1
		Total	19.7647	2.56806	17
Hypodivergent	MALE	Caucasian	23.4000	.	1
		Hispanic	21.4000	1.83848	2
		Asian	23.9000	.	1
		Total	22.5250	1.68992	4
	FEMALE	Caucasian	20.7200	1.86467	5
		Hispanic	24.8000	.	1
		Black	24.2000	.	1
		Asian	20.9000	.	1
		Total	21.6875	2.24273	8
	Total	Caucasian	21.1667	1.99466	6
		Hispanic	22.5333	2.35443	3
		Black	24.2000	.	1
		Asian	22.4000	2.12132	2
		Total	21.9667	2.03708	12
Total	MALE	Caucasian	23.4000	.	1
		Hispanic	19.6000	2.01792	6
		Black	21.1000	.	1
		Asian	21.5333	3.75810	3

		Total	20.6091	2.55556	11
	FEMALE	Caucasian	19.7938	2.25284	16
		Hispanic	19.5636	3.61615	11
		Black	19.2000	3.72111	4
		Asian	18.9500	2.75772	2
		Total	19.5939	2.84022	33
	Total	Caucasian	20.0059	2.35013	17
		Hispanic	19.5765	3.07338	17
		Black	19.5800	3.33272	5
		Asian	20.5000	3.31134	5
		Total	19.8477	2.77845	44

Class III Condylar Height (mm) (R)

Dependent Variable: Condylar Height (R) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	24.4000	8.48528	2
		Asian	20.7000	1.27279	2
		Total	22.5500	5.39475	4
	FEMALE	Caucasian	18.8000	1.27279	2
		Hispanic	18.0000	.	1
		Black	18.8000	.	1
		Total	18.6000	.83666	4
	Total	Caucasian	21.6000	5.91552	4
		Hispanic	18.0000	.	1
		Black	18.8000	.	1
		Asian	20.7000	1.27279	2
		Total	20.5750	4.15099	8
Normodivergent	MALE	Caucasian	21.7400	4.49700	5
		Hispanic	20.2000	2.52290	5
		Black	20.5000	.	1
		Asian	20.8000	3.53553	2
		Middle Eastern/India	19.5000	.	1
		Total	20.8071	3.12372	14
	FEMALE	Caucasian	20.7125	2.87126	8
		Middle Eastern/India	20.7000	.	1
		Total	20.7111	2.68582	9
	Total	Caucasian	21.1077	3.43813	13
		Hispanic	20.2000	2.52290	5
		Black	20.5000	.	1
		Asian	20.8000	3.53553	2
		Middle Eastern/India	20.1000	.84853	2
		Total	20.7696	2.89677	23
Hypodivergent	MALE	Caucasian	24.5500	2.34450	4
		Hispanic	20.1200	2.35945	5
		Black	21.4000	4.52548	2
		Total	21.9636	3.21909	11
	FEMALE	Caucasian	20.0000	3.67514	7
		Hispanic	22.8000	1.21244	3
		Total	20.8400	3.34073	10
	Total	Caucasian	21.6545	3.87592	11
		Hispanic	21.1250	2.35053	8
		Black	21.4000	4.52548	2
		Total	21.4286	3.24563	21
Total	MALE	Caucasian	23.2455	4.36105	11
		Hispanic	20.1600	2.30323	10
		Black	21.1000	3.24191	3
		Asian	20.7500	2.17025	4
		Middle Eastern/India	19.5000	.	1
		Total	21.4862	3.43966	29
	FEMALE	Caucasian	20.1941	3.02768	17

		Hispanic	21.6000	2.59615	4
		Black	18.8000	.	1
		Middle Eastern/India	20.7000	.	1
		Total	20.4000	2.82859	23
	Total	Caucasian	21.3929	3.84437	28
		Hispanic	20.5714	2.38406	14
		Black	20.5250	2.88603	4
		Asian	20.7500	2.17025	4
		Middle Eastern/India	20.1000	.84853	2
		Total	21.0058	3.20058	52

Class I Condylar Height (mm) (L)

Dependent Variable: Condylar Height (L) (mm)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	20.0833	2.32673	6
		FEMALE	18.9143	3.56928	14
		Total	19.2650	3.23163	20
	HISPANIC	MALE	22.2800	1.11669	5
		FEMALE	19.4556	1.90402	9
		Total	20.4643	2.14175	14
	Total	MALE	21.0818*	2.12641	11
		FEMALE	19.1261	2.98652	23
		Total	19.7588	2.85987	34
Normodivergent	CAUCASIAN	MALE	19.9429	2.81827	14
		FEMALE	19.0682	2.69632	44
		Total	19.2793	2.72736	58
	HISPANIC	MALE	19.3385	2.96129	13
		FEMALE	20.5000	3.62131	24
		Total	20.0919	3.40844	37
	Total	MALE	19.6519	2.84840	27
		FEMALE	19.5735	3.10530	68
		Total	19.5958	3.01968	95
Hypodivergent	CAUCASIAN	MALE	20.8263	2.71167	19
		FEMALE	18.8585	3.39676	41
		Total	19.4817	3.30421	60
	HISPANIC	MALE	23.8400	3.23079	5
		FEMALE	20.8250	2.28645	8
		Total	21.9846*	2.97653	13
	Total	MALE	21.4542*	3.02209	24
		FEMALE	19.1796	3.30404	49
		Total	19.9274	3.36940	73
Total	CAUCASIAN	MALE	20.3949	2.66389	39
		FEMALE	18.9596	3.09825	99
		Total	19.3652	3.04230	138
	HISPANIC	MALE	20.9565	3.27759	23
		FEMALE	20.3341	3.06901	41
		Total	20.5578	3.13403	64
	Total	MALE	20.6032	2.89307	62
		FEMALE	19.3621	3.14202	140
		Total	19.7431	3.11392	202

Class II Condylar Height (mm) (L)

Dependent Variable: Condylar Height (L) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	17.0000	.	1
		Asian	23.7000	.	1
		Total	20.3500	4.73762	2
	FEMALE	Caucasian	17.1429	2.88494	7
		Hispanic	16.5500	1.69411	4
		Black	17.5000	.	1
		Asian	16.7000	.	1
		Total	16.9538	2.23257	13
	Total	Caucasian	17.1429	2.88494	7
		Hispanic	16.6400	1.48088	5
		Black	17.5000	.	1
		Asian	20.2000	4.94975	2
		Total	17.4067*	2.70250	15
Normodivergent	MALE	Hispanic	20.1333	1.89297	3
		Black	20.0000	.	1
		Asian	18.6000	.	1
		Total	19.8000	1.49833	5
	FEMALE	Caucasian	18.8750	6.21577	4
		Hispanic	19.8667	2.71195	6
		Black	17.6500	2.19203	2
		Total	19.1667	3.87728	12
	Total	Caucasian	18.8750	6.21577	4
		Hispanic	19.9556	2.34740	9
		Black	18.4333	2.05994	3
		Asian	18.6000	.	1
		Total	19.3529	3.31438	17
Hypodivergent	MALE	Caucasian	22.8000	.	1
		Hispanic	21.7500	1.34350	2
		Asian	24.4000	.	1
		Total	22.6750	1.47281	4
	FEMALE	Caucasian	19.3000	2.51396	5
		Hispanic	24.0000	.	1
		Black	21.3000	.	1
		Asian	16.5000	.	1
		Total	19.7875	2.86129	8
	Total	Caucasian	19.8833	2.66414	6
		Hispanic	22.5000	1.60935	3
		Black	21.3000	.	1
		Asian	20.4500	5.58614	2
		Total	20.7500	2.79691	12
Total	MALE	Caucasian	22.8000	.	1
		Hispanic	20.1500	2.19157	6
		Black	20.0000	.	1
		Asian	22.2333	3.16596	3

		Total	20.9455	2.39097	11
	FEMALE	Caucasian	18.2500	3.71286	16
		Hispanic	19.0364	3.14461	11
		Black	18.5250	2.24258	4
		Asian	16.6000	.14142	2
		Total	18.4455	3.22132	33
	Total	Caucasian	18.5176	3.76052	17
		Hispanic	19.4294	2.82528	17
		Black	18.8200	2.05110	5
		Asian	19.9800	3.81274	5
		Total	19.0705	3.20171	44

Class III Condylar Height (mm) (L)

Dependent Variable: Condylar Height (L) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	25.1000	9.05097	2
		Asian	19.8500	1.20208	2
		Total	22.4750	6.08078	4
	FEMALE	Caucasian	16.8000	1.27279	2
		Hispanic	16.8000	.	1
		Black	17.2000	.	1
		Total	16.9000	.76158	4
	Total	Caucasian	20.9500	7.12811	4
		Hispanic	16.8000	.	1
		Black	17.2000	.	1
		Asian	19.8500	1.20208	2
		Total	19.6875	4.99755	8
Normodivergent	MALE	Caucasian	21.7400	5.23288	5
		Hispanic	20.4600	2.59673	5
		Black	25.7000	.	1
		Asian	27.4500	4.73762	2
		Middle Eastern/India	19.5000	.	1
		Total	22.2214	4.38357	14
	FEMALE	Caucasian	19.0875	3.21223	8
		Middle Eastern/India	20.8000	.	1
		Total	19.2778	3.05850	9
	Total	Caucasian	20.1077	4.11713	13
		Hispanic	20.4600	2.59673	5
		Black	25.7000	.	1
		Asian	27.4500	4.73762	2
		Middle Eastern/India	20.1500	.91924	2
		Total	21.0696	4.11267	23
Hypodivergent	MALE	Caucasian	22.9750	3.29684	4
		Hispanic	20.0000	1.15109	5
		Black	21.5000	4.10122	2
		Total	21.3545	2.72850	11
	FEMALE	Caucasian	18.2286	3.89517	7
		Hispanic	24.4333	1.17189	3
		Total	20.0900	4.40491	10
	Total	Caucasian	19.9545	4.25426	11
		Hispanic	21.6625	2.53261	8
		Black	21.5000	4.10122	2
		Total	20.7524	3.58784	21
Total	MALE	Caucasian	22.8000	4.90286	11
		Hispanic	20.2300	1.90907	10
		Black	22.9000	3.78021	3
		Asian	23.6500	5.21696	4
		Middle Eastern/India	19.5000	.	1
		Total	21.9276	3.96952	29
	FEMALE	Caucasian	18.4647	3.29696	17

		Hispanic	22.5250	3.93478	4
		Black	17.2000	.	1
		Middle Eastern/India	20.8000	.	1
		Total	19.2174	3.56965	23
	Total	Caucasian	20.1679	4.47139	28
		Hispanic	20.8857	2.69326	14
		Black	21.4750	4.20109	4
		Asian	23.6500	5.21696	4
		Middle Eastern/India	20.1500	.91924	2
		Total	20.7288	3.99938	52

Class I Coronoid Process Length (mm) (R)

Descriptive Statistics/ Dependent Variable: Coronoid Length (R)(mm) Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	19.3167	4.32916	6
		FEMALE	16.1429	2.72643	14
		Total	17.0950	3.49924	20
	HISPANIC	MALE	19.4200	3.99149	5
		FEMALE	16.2333	1.76068	9
		Total	17.3714	3.05298	14
	Total	MALE	19.3636*	3.96819	11
		FEMALE	16.1783	2.34985	23
		Total	17.2088	3.27732	34
Normodivergent	CAUCASIAN	MALE	18.5929	2.86369	14
		FEMALE	15.7659	2.89562	44
		Total	16.4483	3.11202	58
	HISPANIC	MALE	16.1538	1.57089	13
		FEMALE	15.8208	2.18751	24
		Total	15.9378	1.97630	37
	Total	MALE	17.4185*	2.60414	27
		FEMALE	15.7853	2.65039	68
		Total	16.2495	2.72599	95
Hypodivergent	CAUCASIAN	MALE	17.0842	2.90961	19
		FEMALE	14.9634	2.72413	41
		Total	15.6350	2.93320	60
	HISPANIC	MALE	19.0600	1.41880	5
		FEMALE	17.0875	2.97727	8
		Total	17.8462	2.61522	13
	Total	MALE	17.4958*	2.76539	24
		FEMALE	15.3102	2.84709	49
		Total	16.0288	2.98592	73
Total	CAUCASIAN	MALE	17.9692	3.17856	39
		FEMALE	15.4869	2.81159	99
		Total	16.1884	3.11697	138
	HISPANIC	MALE	17.4957	2.65903	23
		FEMALE	16.1585	2.27266	41
		Total	16.6391	2.48325	64
	Total	MALE	17.7935	2.98279	62
		FEMALE	15.6836	2.67465	140
		Total	16.3312	2.93240	202

Class II Coronoid Process Length (mm) (R)

Descriptive Statistics
Dependent Variable: Coronoid Length (R) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	17.4000	.	1
		Asian	19.5000	.	1
		Total	18.4500	1.48492	2
	FEMALE	Caucasian	16.7000	3.23780	7
		Hispanic	16.6000	3.06050	4
		Black	19.5000	.	1
		Asian	15.6000	.	1
		Total	16.8000	2.88617	13
	Total	Caucasian	16.7000	3.23780	7
		Hispanic	16.7600	2.67451	5
		Black	19.5000	.	1
		Asian	17.5500	2.75772	2
		Total	17.0200	2.76307	15
Normodivergent	MALE	Hispanic	20.9667	3.70045	3
		Black	13.9000	.	1
		Asian	18.0000	.	1
		Total	18.9600*	4.06177	5
	FEMALE	Caucasian	14.2250	2.05649	4
		Hispanic	13.9500	2.43701	6
		Black	15.8500	.91924	2
		Total	14.3583	2.10517	12
	Total	Caucasian	14.2250	2.05649	4
		Hispanic	16.2889	4.40949	9
		Black	15.2000	1.30000	3
		Asian	18.0000	.	1
		Total	15.7118	3.44127	17
Hypodivergent	MALE	Caucasian	14.8000	.	1
		Hispanic	17.8500	.91924	2
		Asian	15.0000	.	1
		Total	16.3750	1.78582	4
	FEMALE	Caucasian	16.3400	2.39019	5
		Hispanic	14.0000	.	1
		Black	19.4000	.	1
		Asian	16.8000	.	1
		Total	16.4875	2.32160	8
	Total	Caucasian	16.0833	2.22838	6
		Hispanic	16.5667	2.31589	3
		Black	19.4000	.	1
		Asian	15.9000	1.27279	2
		Total	16.4500	2.07430	12
Total	MALE	Caucasian	14.8000	.	1
		Hispanic	19.3333	2.97904	6
		Black	13.9000	.	1
		Asian	17.5000	2.29129	3

		Total	17.9273	3.05421	11
	FEMALE	Caucasian	15.9687	2.76929	16
		Hispanic	14.9182	2.74912	11
		Black	17.6500	2.14554	4
		Asian	16.2000	.84853	2
		Total	15.8364	2.66995	33
	Total	Caucasian	15.9000	2.69629	17
		Hispanic	16.4765	3.49670	17
		Black	16.9000	2.50300	5
		Asian	16.9800	1.81989	5
		Total	16.3591	2.88326	44

Class III Coronoid Process Length (mm) (R)

Dependent Variable: Coronoid Length (R) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	13.4000	3.53553	2
		Asian	18.6000	4.94975	2
		Total	16.0000	4.62025	4
	FEMALE	Caucasian	16.7000	3.39411	2
		Hispanic	11.4000	.	1
		Black	14.2000	.	1
		Total	14.7500	3.19635	4
	Total	Caucasian	15.0500	3.41126	4
		Hispanic	11.4000	.	1
		Black	14.2000	.	1
		Asian	18.6000	4.94975	2
		Total	15.3750	3.73812	8
Normodivergent	MALE	Caucasian	16.0000	1.37659	5
		Hispanic	19.6000	3.40294	5
		Black	19.1000	.	1
		Asian	26.6000	7.91960	2
		Middle Eastern/India	20.6000	.	1
		Total	19.3500*	4.63926	14
	FEMALE	Caucasian	14.3250	2.60645	8
		Middle Eastern/India	12.6000	.	1
		Total	14.1333	2.50500	9
	Total	Caucasian	14.9692	2.30521	13
		Hispanic	19.6000	3.40294	5
		Black	19.1000	.	1
		Asian	26.6000	7.91960	2
		Middle Eastern/India	16.6000	5.65685	2
		Total	17.3087	4.66651	23
Hypodivergent	MALE	Caucasian	17.2250	5.14028	4
		Hispanic	17.7600	1.95780	5
		Black	18.7000	6.64680	2
		Total	17.7364	3.76411	11
	FEMALE	Caucasian	16.3143	3.17670	7
		Hispanic	15.1667	3.68963	3
		Total	15.9700	3.17177	10
	Total	Caucasian	16.6455	3.76732	11
		Hispanic	16.7875	2.80736	8
		Black	18.7000	6.64680	2
		Total	16.8952	3.52540	21
Total	MALE	Caucasian	15.9727	3.44763	11
		Hispanic	18.6800	2.79118	10
		Black	18.8333	4.70567	3
		Asian	22.6000	7.09977	4
		Middle Eastern/India	20.6000	.	1
		Total	18.2759	4.33257	29
	FEMALE	Caucasian	15.4235	2.93780	17

		Hispanic	14.2250	3.55282	4
		Black	14.2000	.	1
		Middle Eastern/India	12.6000	.	1
		Total	15.0391	2.92151	23
	Total	Caucasian	15.6393	3.09699	28
		Hispanic	17.4071	3.55927	14
		Black	17.6750	4.48655	4
		Asian	22.6000	7.09977	4
		Middle Eastern/India	16.6000	5.65685	2
		Total	16.8442	4.07707	52

Class I Coronoid Process Length (mm) (L)

Dependent Variable: Coronoid Length (L) (mm)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	18.5500	3.01048	6
		FEMALE	16.0214	2.57807	14
		Total	16.7800	2.88893	20
	HISPANIC	MALE	18.5800	4.03633	5
		FEMALE	15.6000	2.11778	9
		Total	16.6643	3.15731	14
	Total	MALE	18.5636*	3.32394	11
		FEMALE	15.8565	2.36697	23
		Total	16.7324	2.95560	34
Normodivergent	CAUCASIAN	MALE	17.0786	2.05994	14
		FEMALE	16.7568	3.45700	44
		Total	16.8345	3.16270	58
	HISPANIC	MALE	17.7846	2.44603	13
		FEMALE	15.8167	2.69116	24
		Total	16.5081	2.74382	37
	Total	MALE	17.4185	2.23882	27
		FEMALE	16.4250	3.21885	68
		Total	16.7074	2.99571	95
Hypodivergent	CAUCASIAN	MALE	17.6421	2.85138	19
		FEMALE	16.5195	3.44429	41
		Total	16.8750	3.28642	60
	HISPANIC	MALE	18.6400	1.40107	5
		FEMALE	15.6250	2.25689	8
		Total	16.7846	2.44058	13
	Total	MALE	17.8500*	2.62215	24
		FEMALE	16.3735	3.27724	49
		Total	16.8589	3.13758	73
Total	CAUCASIAN	MALE	17.5795	2.59587	39
		FEMALE	16.5545	3.32069	99
		Total	16.8442	3.15777	138
	HISPANIC	MALE	18.1435	2.59962	23
		FEMALE	15.7317	2.44197	41
		Total	16.5984	2.73980	64
	Total	MALE	17.7887	2.59047	62
		FEMALE	16.3136	3.10350	140
		Total	16.7663	3.02695	202

Class II Coronoid Process Length (mm) (L)

Dependent Variable: Coronoid Length (L) (mm)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	18.5500	3.01048	6
		FEMALE	16.0214	2.57807	14
		Total	16.7800	2.88893	20
	HISPANIC	MALE	18.5800	4.03633	5
		FEMALE	15.6000	2.11778	9
		Total	16.6643	3.15731	14
	Total	MALE	18.5636	3.32394	11
		FEMALE	15.8565	2.36697	23
		Total	16.7324	2.95560	34
Normodivergent	CAUCASIAN	MALE	17.0786	2.05994	14
		FEMALE	16.7568	3.45700	44
		Total	16.8345	3.16270	58
	HISPANIC	MALE	17.7846	2.44603	13
		FEMALE	15.8167	2.69116	24
		Total	16.5081	2.74382	37
	Total	MALE	17.4185*	2.23882	27
		FEMALE	16.4250	3.21885	68
		Total	16.7074	2.99571	95
Hypodivergent	CAUCASIAN	MALE	17.6421	2.85138	19
		FEMALE	16.5195	3.44429	41
		Total	16.8750	3.28642	60
	HISPANIC	MALE	18.6400	1.40107	5
		FEMALE	15.6250	2.25689	8
		Total	16.7846	2.44058	13
	Total	MALE	17.8500	2.62215	24
		FEMALE	16.3735	3.27724	49
		Total	16.8589	3.13758	73
Total	CAUCASIAN	MALE	17.5795	2.59587	39
		FEMALE	16.5545	3.32069	99
		Total	16.8442	3.15777	138
	HISPANIC	MALE	18.1435	2.59962	23
		FEMALE	15.7317	2.44197	41
		Total	16.5984	2.73980	64
	Total	MALE	17.7887	2.59047	62
		FEMALE	16.3136	3.10350	140
		Total	16.7663	3.02695	202

Class III Coronoid Process Length (mm) (L)

Dependent Variable: Coronoid Length (L) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	14.6500	4.31335	2
		Asian	19.6000	3.39411	2
		Total	17.1250	4.26722	4
	FEMALE	Caucasian	18.9000	1.27279	2
		Hispanic	10.6000	.	1
		Black	13.4000	.	1
		Total	15.4500	4.20912	4
	Total	Caucasian	16.7750	3.57246	4
		Hispanic	10.6000	.	1
		Black	13.4000	.	1
		Asian	19.6000	3.39411	2
		Total	16.2875	4.02472	8
Normodivergent	MALE	Caucasian	17.2400	1.93598	5
		Hispanic	20.1200	3.28664	5
		Black	20.4000	.	1
		Asian	23.8500	3.32340	2
		Middle Eastern/India	19.1000	.	1
		Total	19.5714*	3.22787	14
	FEMALE	Caucasian	16.3125	5.12234	8
		Middle Eastern/India	13.4000	.	1
		Total	15.9889	4.88888	9
	Total	Caucasian	16.6692	4.09581	13
		Hispanic	20.1200	3.28664	5
		Black	20.4000	.	1
		Asian	23.8500	3.32340	2
		Middle Eastern/India	16.2500	4.03051	2
		Total	18.1696	4.24783	23
Hypodivergent	MALE	Caucasian	18.7000	6.85468	4
		Hispanic	18.3400	1.84743	5
		Black	18.9000	5.79828	2
		Total	18.5727	4.34490	11
	FEMALE	Caucasian	17.7429	4.56832	7
		Hispanic	18.4667	7.44603	3
		Total	17.9600	5.13381	10
	Total	Caucasian	18.0909	5.18179	11
		Hispanic	18.3875	4.21848	8
		Black	18.9000	5.79828	2
		Total	18.2810	4.62576	21
Total	MALE	Caucasian	17.3000	4.43238	11
		Hispanic	19.2300	2.68289	10
		Black	19.4000	4.19047	3
		Asian	21.7250	3.68001	4
		Middle Eastern/India	19.1000	.	1
		Total	18.8552	3.77440	29
	FEMALE	Caucasian	17.2059	4.50451	17

		Hispanic	16.5000	7.24109	4
		Black	13.4000	.	1
		Middle Eastern/India	13.4000	.	1
		Total	16.7522	4.80614	23
	Total	Caucasian	17.2429	4.39347	28
		Hispanic	18.4500	4.32679	14
		Black	17.9000	4.55046	4
		Asian	21.7250	3.68001	4
		Middle Eastern/India	16.2500	4.03051	2
		Total	17.9250	4.34718	52

Class I Convergence Angle of the Ramus (°) (R)

Dependent Variable: Convergence Angle of Ramus (R) (°)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	14.5000	3.16417	6
		FEMALE	15.9214	2.70446	14
		Total	15.4950*	2.84355	20
	HISPANIC	MALE	12.5200	4.27165	5
		FEMALE	12.1556	2.66182	9
		Total	12.2857	3.16346	14
	Total	MALE	13.6000	3.65705	11
		FEMALE	14.4478	3.22953	23
		Total	14.1735	3.34187	34
Normodivergent	CAUCASIAN	MALE	15.9429	4.47363	14
		FEMALE	14.1568	3.76449	44
		Total	14.5879*	3.98114	58
	HISPANIC	MALE	12.6077	1.98178	13
		FEMALE	12.0875	2.77274	24
		Total	12.2703	2.50686	37
	Total	MALE	14.3370	3.83447	27
		FEMALE	13.4265	3.56746	68
		Total	13.6853	3.64808	95
Hypodivergent	CAUCASIAN	MALE	12.4211	3.04605	19
		FEMALE	13.2073	2.87005	41
		Total	12.9583	2.92426	60
	HISPANIC	MALE	11.3800	3.33272	5
		FEMALE	12.2000	2.13876	8
		Total	11.8846	2.55794	13
	Total	MALE	12.2042	3.06260	24
		FEMALE	13.0429	2.77000	49
		Total	12.7671	2.87557	73
Total	CAUCASIAN	MALE	14.0051	3.90330	39
		FEMALE	14.0131	3.36921	99
		Total	14.0109	3.51370	138
	HISPANIC	MALE	12.3217	2.78175	23
		FEMALE	12.1244	2.57690	41
		Total	12.1953	2.63200	64
	Total	MALE	13.3806	3.59917	62
		FEMALE	13.4600	3.26470	140
		Total	13.4356	3.36204	202

Class II Convergence Angle of the Ramus (°) (R)

Descriptive Statistics
Dependent Variable: Convergence Angle of Ramus (R) (°)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	12.0000	.	1
		Asian	8.3000	.	1
		Total	10.1500	2.61630	2
	FEMALE	Caucasian	12.9429	4.30769	7
		Hispanic	12.5000	4.14648	4
		Black	10.5000	.	1
		Asian	13.3000	.	1
		Total	12.6462	3.74891	13
	Total	Caucasian	12.9429	4.30769	7
		Hispanic	12.4000	3.59792	5
		Black	10.5000	.	1
		Asian	10.8000	3.53553	2
		Total	12.3133	3.64787	15
Normodivergent	MALE	Hispanic	13.0333	2.36291	3
		Black	5.6000	.	1
		Asian	7.4000	.	1
		Total	10.4200	4.00025	5
	FEMALE	Caucasian	12.3750	1.07199	4
		Hispanic	11.8500	1.96647	6
		Black	8.4000	5.37401	2
		Total	11.4500	2.60506	12
	Total	Caucasian	12.3750	1.07199	4
		Hispanic	12.2444	2.04029	9
		Black	7.4667	4.12957	3
		Asian	7.4000	.	1
		Total	11.1471	2.98331	17
Hypodivergent	MALE	Caucasian	15.6000	.	1
		Hispanic	12.4500	.77782	2
		Asian	12.1000	.	1
		Total	13.1500	1.70196	4
	FEMALE	Caucasian	14.7800	3.24145	5
		Hispanic	10.8000	.	1
		Black	13.7000	.	1
		Asian	8.4000	.	1
		Total	13.3500	3.45129	8
	Total	Caucasian	14.9167	2.91850	6
		Hispanic	11.9000	1.10000	3
		Black	13.7000	.	1
		Asian	10.2500	2.61630	2
		Total	13.2833	2.89477	12
Total	MALE	Caucasian	15.6000	.	1
		Hispanic	12.6667	1.59457	6
		Black	5.6000	.	1
		Asian	9.2667	2.49466	3

	Total	11.3636	3.15762	11
FEMALE	Caucasian	13.3750	3.38615	16
	Hispanic	11.9909	2.71089	11
	Black	10.2500	3.98706	4
	Asian	10.8500	3.46482	2
	Total	12.3818	3.28590	33
Total	Caucasian	13.5059	3.32274	17
	Hispanic	12.2294	2.34488	17
	Black	9.3200	4.03076	5
	Asian	9.9000	2.62011	5
	Total	12.1273	3.24850	44

Class III Convergence Angle of the Ramus (°) (R)

Dependent Variable: Convergence Angle of Ramus (R) (°)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	15.8000	.42426	2
		Asian	11.6000	4.52548	2
		Total	13.7000	3.57305	4
	FEMALE	Caucasian	14.2000	3.53553	2
		Hispanic	16.5000	.	1
		Black	8.0000	.	1
		Total	13.2250	4.18041	4
	Total	Caucasian	15.0000	2.25389	4
		Hispanic	16.5000	.	1
		Black	8.0000	.	1
		Asian	11.6000	4.52548	2
		Total	13.4625	3.60909	8
Normodivergent	MALE	Caucasian	16.1200	3.04910	5
		Hispanic	12.1000	3.05123	5
		Black	7.9000	.	1
		Asian	10.6000	1.13137	2
		Middle Eastern/India	15.2000	.	1
		Total	13.2429	3.61593	14
	FEMALE	Caucasian	14.4750	3.62875	8
		Middle Eastern/India	13.2000	.	1
		Total	14.3333	3.42089	9
	Total	Caucasian	15.1077	3.38734	13
		Hispanic	12.1000	3.05123	5
		Black	7.9000	.	1
		Asian	10.6000	1.13137	2
		Middle Eastern/India	14.2000	1.41421	2
		Total	13.6696	3.50395	23
Hypodivergent	MALE	Caucasian	15.6000	1.91311	4
		Hispanic	14.0200	4.58552	5
		Black	10.2000	1.83848	2
		Total	13.9000	3.70783	11
	FEMALE	Caucasian	14.4429	3.57438	7
		Hispanic	11.0333	2.82902	3
		Total	13.4200	3.60672	10
	Total	Caucasian	14.8636	3.01737	11
		Hispanic	12.9000	4.08551	8
		Black	10.2000	1.83848	2
		Total	13.6714	3.57605	21
Total	MALE	Caucasian	15.8727	2.21273	11
		Hispanic	13.0600	3.80882	10
		Black	9.4333	1.85831	3
		Asian	11.1000	2.75439	4
		Middle Eastern/India	15.2000	.	1
		Total	13.5552	3.52801	29
	FEMALE	Caucasian	14.4294	3.36763	17

		Hispanic	12.4000	3.57864	4
		Black	8.0000	.	1
		Middle Eastern/India	13.2000	.	1
		Total	13.7435	3.49270	23
	Total	Caucasian	14.9964	3.00820	28
		Hispanic	12.8714	3.61863	14
		Black	9.0750	1.67804	4
		Asian	11.1000	2.75439	4
		Middle Eastern/India	14.2000	1.41421	2
		Total	13.6385	3.47919	52

Class I Convergence Angle of the Ramus (°) (L)

Dependent Variable: Convergence Angle of Ramus (L) (°)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	12.8667	4.42342	6
		FEMALE	16.0357	2.84189	14
		Total	15.0850*	3.59096	20
	HISPANIC	MALE	13.2800	2.66308	5
		FEMALE	9.6000	2.50300	9
		Total	10.9143	3.06365	14
	Total	MALE	13.0545	3.55903	11
		FEMALE	13.5174*	4.16704	23
		Total	13.3676	3.93228	34
Normodivergent	CAUCASIAN	MALE	15.6500	3.40988	14
		FEMALE	14.0091	4.08205	44
		Total	14.4052*	3.96535	58
	HISPANIC	MALE	13.1462	2.92877	13
		FEMALE	12.2458	3.74816	24
		Total	12.5622	3.46766	37
	Total	MALE	14.4444	3.37608	27
		FEMALE	13.3868	4.02959	68
		Total	13.6874	3.86733	95
Hypodivergent	CAUCASIAN	MALE	14.9263	2.98735	19
		FEMALE	13.1829	3.54308	41
		Total	13.7350	3.44997	60
	HISPANIC	MALE	10.9400	2.82631	5
		FEMALE	12.9000	3.02183	8
		Total	12.1462	2.99572	13
	Total	MALE	14.0958	3.33290	24
		FEMALE	13.1367	3.43570	49
		Total	13.4521	3.40935	73
Total	CAUCASIAN	MALE	14.8692	3.41160	39
		FEMALE	13.9535	3.79154	99
		Total	14.2123	3.69905	138
	HISPANIC	MALE	12.6957	2.88420	23
		FEMALE	11.7927	3.51841	41
		Total	12.1172	3.30990	64
	Total	MALE	14.0629	3.37212	62
		FEMALE	13.3207	3.83037	140
		Total	13.5485	3.70336	202

Class II Convergence Angle of the Ramus (°) (L)

Dependent Variable: Convergence Angle of Ramus (L) (°)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	14.1000	.	1
		Asian	8.3000	.	1
		Total	11.2000	4.10122	2
	FEMALE	Caucasian	14.5429	6.07367	7
		Hispanic	12.5000	1.86369	4
		Black	6.1000	.	1
		Asian	16.0000	.	1
		Total	13.3769	5.03474	13
	Total	Caucasian	14.5429	6.07367	7
		Hispanic	12.8200	1.76550	5
		Black	6.1000	.	1
		Asian	12.1500	5.44472	2
		Total	13.0867	4.84928	15
Normodivergent	MALE	Hispanic	12.6000	.86603	3
		Black	5.5000	.	1
		Asian	13.9000	.	1
		Total	11.4400	3.42316	5
	FEMALE	Caucasian	16.0500	5.10457	4
		Hispanic	14.3167	2.95189	6
		Black	8.2500	2.61630	2
		Total	13.8833	4.38962	12
	Total	Caucasian	16.0500	5.10457	4
		Hispanic	13.7444	2.52394	9
		Black	7.3333	2.43790	3
		Asian	13.9000	.	1
		Total	13.1647	4.18254	17
Hypodivergent	MALE	Caucasian	11.9000	.	1
		Hispanic	18.0500	9.40452	2
		Asian	11.8000	.	1
		Total	14.9500	6.50359	4
	FEMALE	Caucasian	13.7800	3.73256	5
		Hispanic	13.7000	.	1
		Black	13.8000	.	1
		Asian	4.6000	.	1
		Total	12.6250	4.29842	8
	Total	Caucasian	13.4667	3.42559	6
		Hispanic	16.6000	7.10845	3
		Black	13.8000	.	1
		Asian	8.2000	5.09117	2
		Total	13.4000	4.96021	12
Total	MALE	Caucasian	11.9000	.	1
		Hispanic	14.6667	5.01943	6
		Black	5.5000	.	1
		Asian	11.3333	2.82902	3
		Total	12.6727	4.72506	11

	FEMALE	Caucasian	14.6813	4.94587	16
		Hispanic	13.6000	2.48837	11
		Black	9.1000	3.62307	4
		Asian	10.3000	8.06102	2
		Total	13.3788	4.51759	33
	Total	Caucasian	14.5176	4.83609	17
		Hispanic	13.9765	3.46690	17
		Black	8.3800	3.52661	5
		Asian	10.9200	4.53509	5
		Total	13.2023	4.52499	44

Class III Convergence Angle of the Ramus (°) (L)

Dependent Variable: Convergence Angle of Ramus (L) (°)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	10.1500	.35355	2
		Asian	11.8000	2.12132	2
		Total	10.9750	1.56498	4
	FEMALE	Caucasian	17.8000	4.94975	2
		Hispanic	17.2000	.	1
		Black	7.0000	.	1
		Total	14.9500	6.02799	4
	Total	Caucasian	13.9750	5.26458	4
		Hispanic	17.2000	.	1
		Black	7.0000	.	1
		Asian	11.8000	2.12132	2
		Total	12.9625	4.59750	8
Normodivergent	MALE	Caucasian	16.9000	4.89030	5
		Hispanic	14.1400	3.50899	5
		Black	15.7000	.	1
		Asian	13.4000	.70711	2
		Middle Eastern/India	18.0000	.	1
		Total	15.4071*	3.71535	14
	FEMALE	Caucasian	11.6250	4.30374	8
		Middle Eastern/India	11.6000	.	1
		Total	11.6222	4.02578	9
	Total	Caucasian	13.6538	5.09029	13
		Hispanic	14.1400	3.50899	5
		Black	15.7000	.	1
		Asian	13.4000	.70711	2
		Middle Eastern/India	14.8000	4.52548	2
		Total	13.9261	4.19732	23
Hypodivergent	MALE	Caucasian	15.4750	2.78253	4
		Hispanic	10.8000	2.19886	5
		Black	13.7000	4.94975	2
		Total	13.0273	3.41675	11
	FEMALE	Caucasian	12.8000	2.72152	7
		Hispanic	11.2333	2.95691	3
		Total	12.3300	2.73010	10
	Total	Caucasian	13.7727	2.93056	11
		Hispanic	10.9625	2.30461	8
		Black	13.7000	4.94975	2
		Total	12.6952	3.05262	21
Total	MALE	Caucasian	15.1545	4.29822	11
		Hispanic	12.4700	3.27416	10
		Black	14.3667	3.68556	3
		Asian	12.6000	1.58745	4
		Middle Eastern/India	18.0000	.	1
		Total	13.8931	3.67394	29
	FEMALE	Caucasian	12.8353	4.02817	17

		Hispanic	12.7250	3.83786	4
		Black	7.0000	.	1
		Middle Eastern/India	11.6000	.	1
		Total	12.5087	3.91372	23
	Total	Caucasian	13.7464	4.21764	28
		Hispanic	12.5429	3.29165	14
		Black	12.5250	4.75631	4
		Asian	12.6000	1.58745	4
		Middle Eastern/India	14.8000	4.52548	2
		Total	13.2808	3.80789	52

Class I Anterior Mandibular Height (mm)

Dependent Variable: Anterior Mandibular Height (mm)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	36.7667*	2.97030	6
		FEMALE	32.2786	4.14342	14
		Total	33.6250	4.30359	20
	HISPANIC	MALE	36.1800	2.75082	5
		FEMALE	32.2111	3.36840	9
		Total	33.6286	3.63391	14
	Total	MALE	36.5000	2.74445	11
		FEMALE	32.2522	3.77779	23
		Total	33.6265	3.98317	34
Normodivergent	CAUCASIAN	MALE	34.9500	1.96146	14
		FEMALE	30.7455	2.55902	44
		Total	31.7603	3.01854	58
	HISPANIC	MALE	35.2385	2.02589	13
		FEMALE	31.0417	2.84481	24
		Total	32.5162	3.26560	37
	Total	MALE	35.0889*	1.95946	27
		FEMALE	30.8500	2.64601	68
		Total	32.0547	3.12195	95
Hypodivergent	CAUCASIAN	MALE	33.0684	2.91815	19
		FEMALE	29.0390	2.64640	41
		Total	30.3150	3.30438	60
	HISPANIC	MALE	32.8800	1.81025	5
		FEMALE	28.6125	2.28438	8
		Total	30.2538	2.96749	13
	Total	MALE	33.0292*	2.69080	24
		FEMALE	28.9694	2.57344	49
		Total	30.3041*	3.22733	73
Total	CAUCASIAN	MALE	34.3128	2.89575	39
		FEMALE	30.2556	3.05301	99
		Total	31.4022	3.51498	138
	HISPANIC	MALE	34.9304	2.36152	23
		FEMALE	30.8244	3.04555	41
		Total	32.3000	3.43215	64
	Total	MALE	34.5419	2.70655	62
		FEMALE	30.4221	3.05094	140
		Total	31.6866	3.50551	202

Class II Anterior Mandibular Height (mm)

Dependent Variable: Anterior Mandibular Height (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	38.1000	.	1
		Asian	30.0000	.	1
		Total	34.0500	5.72756	2
	FEMALE	Caucasian	32.8000	2.83960	7
		Hispanic	32.8500	2.15793	4
		Black	40.1000	.	1
		Asian	36.2000	.	1
		Total	33.6385	3.13675	13
	Total	Caucasian	32.8000	2.83960	7
		Hispanic	33.9000	3.00083	5
		Black	40.1000	.	1
		Asian	33.1000	4.38406	2
		Total	33.6933*	3.28600	15
Normodivergent	MALE	Hispanic	34.2000	1.15326	3
		Black	40.4000	.	1
		Asian	35.2000	.	1
		Total	35.6400	2.81656	5
	FEMALE	Caucasian	31.2750	1.48408	4
		Hispanic	32.5833	3.07728	6
		Black	36.2500	3.18198	2
		Total	32.7583	2.97641	12
	Total	Caucasian	31.2750	1.48408	4
		Hispanic	33.1222	2.62763	9
		Black	37.6333	3.28684	3
		Asian	35.2000	.	1
		Total	33.6059	3.14731	17
Hypodivergent	MALE	Caucasian	31.9000	.	1
		Hispanic	31.0500	.35355	2
		Asian	35.5000	.	1
		Total	32.3750	2.13131	4
	FEMALE	Caucasian	27.5200	1.31415	5
		Hispanic	33.9000	.	1
		Black	31.6000	.	1
		Asian	32.7000	.	1
		Total	29.4750	2.94024	8
	Total	Caucasian	28.2500	2.13986	6
		Hispanic	32.0000	1.66433	3
		Black	31.6000	.	1
		Asian	34.1000	1.97990	2
		Total	30.4417	2.96294	12
Total	MALE	Caucasian	31.9000	.	1
		Hispanic	33.8000	2.71588	6
		Black	40.4000	.	1
		Asian	33.5667	3.09246	3
		Total	34.1636	3.19195	11

	FEMALE	Caucasian	30.7688	3.10456	16
		Hispanic	32.8000	2.50639	11
		Black	36.0500	3.93319	4
		Asian	34.4500	2.47487	2
		Total	32.3091	3.38049	33
	Total	Caucasian	30.8353	3.01847	17
		Hispanic	33.1529	2.54439	17
		Black	36.9200	3.92263	5
		Asian	33.9200	2.55871	5
		Total	32.7727	3.39612	44

Class III Anterior Mandibular Height (mm)

Dependent Variable: Anterior Mandibular Height (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	37.6000	4.94975	2
		Asian	33.5000	5.79828	2
		Total	35.5500*	4.99767	4
	FEMALE	Caucasian	25.8000	.14142	2
		Hispanic	29.8000	.	1
		Black	30.8000	.	1
		Total	28.0500	2.63122	4
	Total	Caucasian	31.7000	7.38828	4
		Hispanic	29.8000	.	1
		Black	30.8000	.	1
		Asian	33.5000	5.79828	2
		Total	31.8000	5.45370	8
Normodivergent	MALE	Caucasian	33.4600	1.97813	5
		Hispanic	33.9600	3.07295	5
		Black	33.1000	.	1
		Asian	34.7000	2.68701	2
		Middle Eastern/India	35.6000	.	1
		Total	33.9429*	2.26026	14
	FEMALE	Caucasian	30.3250	2.76961	8
		Middle Eastern/India	29.4000	.	1
		Total	30.2222	2.60901	9
	Total	Caucasian	31.5308	2.88079	13
		Hispanic	33.9600	3.07295	5
		Black	33.1000	.	1
		Asian	34.7000	2.68701	2
		Middle Eastern/India	32.5000	4.38406	2
		Total	32.4870	2.99018	23
Hypodivergent	MALE	Caucasian	31.0500	3.04904	4
		Hispanic	32.6200	2.45194	5
		Black	36.8000	2.68701	2
		Total	32.8091*	3.21822	11
	FEMALE	Caucasian	27.3429	1.95777	7
		Hispanic	29.9000	2.08806	3
		Total	28.1100	2.24720	10
	Total	Caucasian	28.6909	2.93034	11
		Hispanic	31.6000	2.58125	8
		Black	36.8000	2.68701	2
		Total	30.5714	3.63788	21
Total	MALE	Caucasian	33.3364	3.54098	11
		Hispanic	33.2900	2.71434	10
		Black	35.5667	2.85890	3
		Asian	34.1000	3.75411	4
		Middle Eastern/India	35.6000	.	1
		Total	33.7345	3.09450	29
	FEMALE	Caucasian	28.5647	2.82000	17

		Hispanic	29.8750	1.70563	4
		Black	30.8000	.	1
		Middle Eastern/India	29.4000	.	1
		Total	28.9261	2.57191	23
	Total	Caucasian	30.4393	3.87149	28
		Hispanic	32.3143	2.88707	14
		Black	34.3750	3.33604	4
		Asian	34.1000	3.75411	4
		Middle Eastern/India	32.5000	4.38406	2
		Total	31.6077	3.73173	52

Class I Convergence Angle of the Base of Mandible (°)

Dependent Variable: Convergence Angle of the Base of Mandible (°)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	73.9500	9.30005	6
		FEMALE	71.8500	4.21695	14
		Total	72.4800	5.99189	20
	HISPANIC	MALE	71.2600	7.04720	5
		FEMALE	69.2000	6.56144	9
		Total	69.9357	6.54401	14
	Total	MALE	72.7273	8.06748	11
		FEMALE	70.8130	5.28319	23
		Total	71.4324	6.25754	34
Normodivergent	CAUCASIAN	MALE	70.6071	5.84090	14
		FEMALE	69.1205	4.93542	44
		Total	69.4793	5.15445	58
	HISPANIC	MALE	69.1538	3.94221	13
		FEMALE	67.4375	4.43316	24
		Total	68.0405	4.29259	37
	Total	MALE	69.9074	4.97779	27
		FEMALE	68.5265	4.79958	68
		Total	68.9189	4.86466	95
Hypodivergent	CAUCASIAN	MALE	64.9316	4.77796	19
		FEMALE	65.2000	5.63644	41
		Total	65.1150	5.34034	60
	HISPANIC	MALE	66.5000	7.08978	5
		FEMALE	63.7875	4.17285	8
		Total	64.8308	5.36647	13
	Total	MALE	65.2583	5.19916	24
		FEMALE	64.9694	5.41222	49
		Total	65.0644*	5.30865	73

Class II Convergence Angle of the Base of Mandible (°)

Descriptive Statistics
Dependent Variable: Convergence Angle of the Base of Mandible (°)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	79.8000	.	1
		Asian	66.5000	.	1
		Total	73.1500	9.40452	2
	FEMALE	Caucasian	73.2429	6.28221	7
		Hispanic	73.9250	1.96871	4
		Black	76.2000	.	1
		Asian	89.8000	.	1
		Total	74.9538	6.42334	13
	Total	Caucasian	73.2429	6.28221	7
		Hispanic	75.1000	3.13209	5
		Black	76.2000	.	1
		Asian	78.1500	16.47559	2
		Total	74.7133*	6.48734	15
Normodivergent	MALE	Hispanic	66.9000	7.70779	3
		Black	60.4000	.	1
		Asian	73.1000	.	1
		Total	66.8400	7.06208	5
	FEMALE	Caucasian	66.6250	5.95280	4
		Hispanic	69.8500	2.33645	6
		Black	58.0500	.35355	2
		Total	66.8083	5.58235	12
	Total	Caucasian	66.6250	5.95280	4
		Hispanic	68.8667	4.52106	9
		Black	58.8333	1.37961	3
		Asian	73.1000	.	1
		Total	66.8176	5.82175	17
Hypodivergent	MALE	Caucasian	74.2000	.	1
		Hispanic	69.0500	8.41457	2
		Asian	68.8000	.	1
		Total	70.2750	5.51928	4
	FEMALE	Caucasian	62.1800	3.88999	5
		Hispanic	74.5000	.	1
		Black	65.0000	.	1
		Asian	64.5000	.	1
		Total	64.3625	5.17603	8
	Total	Caucasian	64.1833	6.01545	6
		Hispanic	70.8667	6.73078	3
		Black	65.0000	.	1
		Asian	66.6500	3.04056	2
		Total	66.3333	5.81649	12
Total	MALE	Caucasian	74.2000	.	1
		Hispanic	69.7667	7.94951	6
		Black	60.4000	.	1
		Asian	69.4667	3.35012	3

		Total	69.2364	6.65572	11
	FEMALE	Caucasian	68.1313	7.17725	16
		Hispanic	71.7545	2.95072	11
		Black	64.3250	8.57025	4
		Asian	77.1500	17.88980	2
		Total	69.4242	7.31014	33
	Total	Caucasian	68.4882	7.10351	17
		Hispanic	71.0529	5.11360	17
		Black	63.5400	7.62679	5
		Asian	72.5400	10.16528	5
		Total	69.3773	7.07649	44

Class III Convergence Angle of the Base of Mandible (°)

Dependent Variable: Convergence Angle of the Base of Mandible (°)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	68.2500	2.47487	2
		Asian	74.0500	6.57609	2
		Total	71.1500	5.26023	4
	FEMALE	Caucasian	75.1000	1.97990	2
		Hispanic	66.8000	.	1
		Black	63.0000	.	1
		Total	70.0000	6.19624	4
	Total	Caucasian	71.6750	4.35766	4
		Hispanic	66.8000	.	1
		Black	63.0000	.	1
		Asian	74.0500	6.57609	2
		Total	70.5750	5.35637	8
Normodivergent	MALE	Caucasian	69.2000	5.24071	5
		Hispanic	72.2600	4.38668	5
		Black	59.4000	.	1
		Asian	72.7500	6.43467	2
		Middle Eastern/India	71.8000	.	1
		Total	70.2857	5.45300	14
	FEMALE	Caucasian	68.5625	5.75151	8
		Middle Eastern/India	62.0000	.	1
		Total	67.8333	5.80775	9
	Total	Caucasian	68.8077	5.34376	13
		Hispanic	72.2600	4.38668	5
		Black	59.4000	.	1
		Asian	72.7500	6.43467	2
		Middle Eastern/India	66.9000	6.92965	2
		Total	69.3261	5.59766	23
Hypodivergent	MALE	Caucasian	72.0750	3.59757	4
		Hispanic	67.3000	3.67355	5
		Black	56.8500	13.08148	2
		Total	67.1364	7.57130	11
	FEMALE	Caucasian	65.6429	3.23154	7
		Hispanic	63.9333	3.31713	3
		Total	65.1300	3.17632	10
	Total	Caucasian	67.9818	4.54749	11
		Hispanic	66.0375	3.72710	8
		Black	56.8500	13.08148	2
		Total	66.1810	5.85292	21
Total	MALE	Caucasian	70.0727	4.25796	11
		Hispanic	69.7800	4.62428	10
		Black	57.7000	9.36643	3
		Asian	73.4000	5.36470	4
		Middle Eastern/India	71.8000	.	1
		Total	69.2103	6.32841	29
	FEMALE	Caucasian	68.1294	5.24461	17

		Hispanic	64.6500	3.06431	4
		Black	63.0000	.	1
		Middle Eastern/India	62.0000	.	1
		Total	67.0348	5.01367	23
	Total	Caucasian	68.8929	4.89375	28
		Hispanic	68.3143	4.77024	14
		Black	59.0250	8.09377	4
		Asian	73.4000	5.36470	4
		Middle Eastern/India	66.9000	6.92965	2
		Total	68.2481	5.83278	52

Class I 2D Ramus Height (mm)

Dependent Variable: Ramus Height - 2D Ceph (mm)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	65.0333	5.33467	6
		FEMALE	60.2214	3.70513	14
		Total	61.6650	4.69045	20
	HISPANIC	MALE	63.5200	3.02605	5
		FEMALE	59.5222	4.26842	9
		Total	60.9500	4.24042	14
	Total	MALE	64.3455	4.30311	11
		FEMALE	59.9478	3.85473	23
		Total	61.3706	4.45846	34
Normodivergent	CAUCASIAN	MALE	68.6000	4.18587	14
		FEMALE	60.2591	4.07147	44
		Total	62.2724	5.42812	58
	HISPANIC	MALE	70.0662	4.66543	13
		FEMALE	61.9875	3.94355	24
		Total	64.8259	5.69898	37
	Total	MALE	69.3059	4.40046	27
		FEMALE	60.8691	4.08288	68
		Total	63.2669	5.64555	95
Hypodivergent	CAUCASIAN	MALE	73.3000	6.57056	19
		FEMALE	62.8317	3.72286	41
		Total	66.1467	6.83246	60
	HISPANIC	MALE	72.2600	5.16846	5
		FEMALE	61.0000	5.46312	8
		Total	65.3308	7.66968	13
	Total	MALE	73.0833	6.21441	24
		FEMALE	62.5327	4.04601	49
		Total	66.0014	6.93949	73
Total	CAUCASIAN	MALE	70.3410	6.33494	39
		FEMALE	61.3192	4.04789	99
		Total	63.8688	6.28288	138
	HISPANIC	MALE	69.1200	5.31896	23
		FEMALE	61.2537	4.33815	41
		Total	64.0806	6.02501	64
	Total	MALE	69.8881	5.96297	62
		FEMALE	61.3000	4.11934	140
		Total	63.9359	6.18815	202

Class II 2D Ramus Height (mm)

Descriptive Statistics
Dependent Variable: Ramus Height - 2D Ceph (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	64.8000	.	1
		Asian	68.2000	.	1
		Total	66.5000	2.40416	2
	FEMALE	Caucasian	55.6714	1.83004	7
		Hispanic	53.3750	5.19383	4
		Black	57.1000	.	1
		Asian	57.5000	.	1
		Total	55.2154	3.22486	13
	Total	Caucasian	55.6714	1.83004	7
		Hispanic	55.6600	6.80720	5
		Black	57.1000	.	1
		Asian	62.8500	7.56604	2
		Total	56.7200	5.00931	15
Normodivergent	MALE	Hispanic	68.7333	2.49065	3
		Black	75.2000	.	1
		Asian	68.8000	.	1
		Total	70.0400	3.37979	5
	FEMALE	Caucasian	63.6500	.66583	4
		Hispanic	61.5333	3.08394	6
		Black	61.0500	1.48492	2
		Total	62.1583	2.42692	12
	Total	Caucasian	63.6500	.66583	4
		Hispanic	63.9333	4.52272	9
		Black	65.7667	8.23671	3
		Asian	68.8000	.	1
		Total	64.4765	4.53962	17
Hypodivergent	MALE	Caucasian	67.9000	.	1
		Hispanic	66.6500	3.88909	2
		Asian	66.5000	.	1
		Total	66.9250	2.33862	4
	FEMALE	Caucasian	60.1960	4.43092	5
		Hispanic	68.9000	.	1
		Black	66.6000	.	1
		Asian	65.7000	.	1
		Total	62.7725	4.96402	8
	Total	Caucasian	61.4800	5.05949	6
		Hispanic	67.4000	3.04138	3
		Black	66.6000	.	1
		Asian	66.1000	.56569	2
		Total	64.1567	4.62090	12
Total	MALE	Caucasian	67.9000	.	1
		Hispanic	67.3833	2.85476	6
		Black	75.2000	.	1
		Asian	67.8333	1.19304	3

		Total	68.2636	3.11521	11
	FEMALE	Caucasian	59.0800	4.25090	16
		Hispanic	59.2364	6.25256	11
		Black	61.4500	3.99875	4
		Asian	61.6000	5.79828	2
		Total	59.5721	4.90864	33
	Total	Caucasian	59.5988	4.63862	17
		Hispanic	62.1118	6.56400	17
		Black	64.2000	7.05727	5
		Asian	65.3400	4.55774	5
		Total	61.7450	5.88910	44

Class III 2D Ramus Height (mm)

Dependent Variable: Ramus Height - 2D Ceph (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	70.0000	7.07107	2
		Asian	71.2000	5.79828	2
		Total	70.6000	5.32478	4
	FEMALE	Caucasian	51.5500	1.48492	2
		Hispanic	56.6000	.	1
		Black	61.9000	.	1
		Total	55.4000	5.01797	4
	Total	Caucasian	60.7750	11.43981	4
		Hispanic	56.6000	.	1
		Black	61.9000	.	1
		Asian	71.2000	5.79828	2
		Total	63.0000	9.43156	8
Normodivergent	MALE	Caucasian	71.1600	3.17222	5
		Hispanic	69.3200	7.46840	5
		Black	64.9000	.	1
		Asian	68.0000	12.44508	2
		Middle Eastern/India	75.7000	.	1
		Total	69.9286	6.16260	14
	FEMALE	Caucasian	63.0250	5.20076	8
		Middle Eastern/India	62.0000	.	1
		Total	62.9111	4.87684	9
	Total	Caucasian	66.1538	6.00841	13
		Hispanic	69.3200	7.46840	5
		Black	64.9000	.	1
		Asian	68.0000	12.44508	2
		Middle Eastern/India	68.8500	9.68736	2
		Total	67.1826	6.58425	23
Hypodivergent	MALE	Caucasian	73.3250	5.66650	4
		Hispanic	70.2600	8.19347	5
		Black	69.3000	.98995	2
		Total	71.2000	6.28920	11
	FEMALE	Caucasian	62.1429	4.05004	7
		Hispanic	64.5667	3.25628	3
		Total	62.8700	3.82914	10
	Total	Caucasian	66.2091	7.16260	11
		Hispanic	68.1250	7.07627	8
		Black	69.3000	.98995	2
		Total	67.2333	6.67445	21
Total	MALE	Caucasian	71.7364	4.52068	11
		Hispanic	69.7900	7.40757	10
		Black	67.8333	2.63502	3
		Asian	69.6000	8.13921	4
		Middle Eastern/India	75.7000	.	1
		Total	70.5034	5.92907	29
	FEMALE	Caucasian	61.3118	5.63947	17

		Hispanic	62.5750	4.78914	4
		Black	61.9000	.	1
		Middle Eastern/India	62.0000	.	1
		Total	61.5870	5.14837	23
	Total	Caucasian	65.4071	7.30043	28
		Hispanic	67.7286	7.39745	14
		Black	66.3500	3.66470	4
		Asian	69.6000	8.13921	4
		Middle Eastern/India	68.8500	9.68736	2
		Total	66.5596	7.12249	52

Class I Maximum Ramus Breadth (mm) (R)

Dependent Variable: Maximum Ramus Breadth (R) (mm)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	41.6117	3.38113	6
		FEMALE	38.7679	2.85385	14
		Total	39.6210	3.22004	20
	HISPANIC	MALE	42.0980	4.09323	5
		FEMALE	38.5056	3.51488	9
		Total	39.7886	3.99361	14
	Total	MALE	41.8327*	3.53303	11
		FEMALE	38.6652	3.05324	23
		Total	39.6900	3.50139	34
Normodivergent	CAUCASIAN	MALE	41.0850	3.89936	14
		FEMALE	39.8743	2.48414	44
		Total	40.1666	2.89762	58
	HISPANIC	MALE	40.1054	3.41188	13
		FEMALE	39.7317	2.57681	24
		Total	39.8630	2.85573	37
	Total	MALE	40.6133*	3.63649	27
		FEMALE	39.8240	2.49891	68
		Total	40.0483	2.86997	95
Hypodivergent	CAUCASIAN	MALE	42.6021	2.41385	19
		FEMALE	39.4907	2.26241	41
		Total	40.4760	2.71626	60
	HISPANIC	MALE	42.8660	4.03711	5
		FEMALE	40.1825	2.18711	8
		Total	41.2146	3.17326	13
	Total	MALE	42.6571*	2.72149	24
		FEMALE	39.6037	2.24270	49
		Total	40.6075	2.79377	73
Total	CAUCASIAN	MALE	41.9051	3.15757	39
		FEMALE	39.5590	2.45219	99
		Total	40.2220	2.86199	138
	HISPANIC	MALE	41.1387	3.72523	23
		FEMALE	39.5505	2.73335	41
		Total	40.1213	3.19055	64
	Total	MALE	41.6208	3.36975	62
		FEMALE	39.5565	2.52775	140
		Total	40.1901	2.96239	202

Class II Maximum Ramus Breadth (mm) (R)

Descriptive Statistics
Dependent Variable: Maximum Ramus Breadth (R) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	40.7000	.	1
		Asian	43.7000	.	1
		Total	42.2000	2.12132	2
	FEMALE	Caucasian	38.9929	4.65673	7
		Hispanic	39.2375	2.03280	4
		Black	38.0000	.	1
		Asian	35.4000	.	1
		Total	38.7154	3.60140	13
	Total	Caucasian	38.9929	4.65673	7
		Hispanic	39.5300	1.87803	5
		Black	38.0000	.	1
		Asian	39.5500	5.86899	2
		Total	39.1800	3.59750	15
Normodivergent	MALE	Hispanic	41.5633	2.62127	3
		Black	44.1000	.	1
		Asian	37.1000	.	1
		Total	41.1780	3.13671	5
	FEMALE	Caucasian	39.4050	4.02924	4
		Hispanic	36.4983	3.00540	6
		Black	40.7000	3.95980	2
		Total	38.1675	3.63338	12
	Total	Caucasian	39.4050	4.02924	4
		Hispanic	38.1867	3.71168	9
		Black	41.8333	3.41955	3
		Asian	37.1000	.	1
		Total	39.0529	3.67899	17
Hypodivergent	MALE	Caucasian	47.9000	.	1
		Hispanic	40.5000	.84853	2
		Asian	42.1000	.	1
		Total	42.7500	3.54918	4
	FEMALE	Caucasian	40.0260	3.89909	5
		Hispanic	41.2000	.	1
		Black	44.8500	.	1
		Asian	38.8000	.	1
		Total	40.6225	3.46652	8
	Total	Caucasian	41.3383	4.74295	6
		Hispanic	40.7333	.72342	3
		Black	44.8500	.	1
		Asian	40.4500	2.33345	2
		Total	41.3317	3.48995	12
Total	MALE	Caucasian	47.9000	.	1
		Hispanic	41.0650	1.78767	6
		Black	44.1000	.	1
		Asian	40.9667	3.44287	3

		Total	41.9355	2.95480	11
	FEMALE	Caucasian	39.4187	4.02278	16
		Hispanic	37.9218	2.95614	11
		Black	41.0625	3.63625	4
		Asian	37.1000	2.40416	2
		Total	38.9785	3.60290	33
	Total	Caucasian	39.9176	4.40484	17
		Hispanic	39.0312	2.97618	17
		Black	41.6700	3.42958	5
		Asian	39.4200	3.44340	5
		Total	39.7177	3.65625	44

Class III Maximum Ramus Breadth (mm) (R)

Dependent Variable: Maximum Ramus Breadth (R) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	41.0000	10.46518	2
		Asian	45.0500	.63640	2
		Total	43.0250	6.48916	4
	FEMALE	Caucasian	38.8950	3.68403	2
		Hispanic	31.3000	.	1
		Black	39.8000	.	1
		Total	37.2225	4.50504	4
	Total	Caucasian	39.9475	6.51979	4
		Hispanic	31.3000	.	1
		Black	39.8000	.	1
		Asian	45.0500	.63640	2
		Total	40.1237	6.03030	8
Normodivergent	MALE	Caucasian	42.5060	2.90632	5
		Hispanic	44.0000	2.48898	5
		Black	43.1100	.	1
		Asian	46.3000	1.97990	2
		Middle Eastern/India	42.5000	.	1
		Total	43.6243*	2.56144	14
	FEMALE	Caucasian	39.1150	2.13316	8
		Middle Eastern/India	41.2000	.	1
		Total	39.3467	2.11296	9
	Total	Caucasian	40.4192	2.90144	13
		Hispanic	44.0000	2.48898	5
		Black	43.1100	.	1
		Asian	46.3000	1.97990	2
		Middle Eastern/India	41.8500	.91924	2
		Total	41.9504	3.17126	23
Hypodivergent	MALE	Caucasian	42.6575	5.05232	4
		Hispanic	41.2600	1.81191	5
		Black	40.4000	2.54558	2
		Total	41.6118	3.22675	11
	FEMALE	Caucasian	41.2329	3.60262	7
		Hispanic	40.9000	2.62869	3
		Total	41.1330	3.19594	10
	Total	Caucasian	41.7509	3.99521	11
		Hispanic	41.1250	1.97104	8
		Black	40.4000	2.54558	2
		Total	41.3838	3.14043	21
Total	MALE	Caucasian	42.2873	4.73272	11
		Hispanic	42.6300	2.50956	10
		Black	41.3033	2.38496	3
		Asian	45.6750	1.40089	4
		Middle Eastern/India	42.5000	.	1
		Total	42.7783	3.48963	29
	FEMALE	Caucasian	39.9612	2.98559	17

		Hispanic	38.5000	5.25801	4
		Black	39.8000	.	1
		Middle Eastern/India	41.2000	.	1
		Total	39.7539	3.26603	23
	Total	Caucasian	40.8750	3.86217	28
		Hispanic	41.4500	3.80642	14
		Black	40.9275	2.08735	4
		Asian	45.6750	1.40089	4
		Middle Eastern/India	41.8500	.91924	2
		Total	41.4406	3.68614	52

Class I Maximum Ramus Breadth (mm) (L)

Dependent Variable: Maximum Ramus Breadth (L) (mm)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	40.0867	2.89739	6
		FEMALE	39.3093	3.32778	14
		Total	39.5425	3.14957	20
	HISPANIC	MALE	43.1180	3.50116	5
		FEMALE	39.3722	2.58986	9
		Total	40.7100	3.37172	14
	Total	MALE	41.4645*	3.40687	11
		FEMALE	39.3339	2.99730	23
		Total	40.0232	3.24500	34
Normodivergent	CAUCASIAN	MALE	41.4521	3.06645	14
		FEMALE	39.7525	3.18410	44
		Total	40.1628	3.21422	58
	HISPANIC	MALE	40.2854	4.96451	13
		FEMALE	40.0350	2.85868	24
		Total	40.1230	3.66758	37
	Total	MALE	40.8904*	4.05336	27
		FEMALE	39.8522	3.05461	68
		Total	40.1473	3.37884	95
Hypodivergent	CAUCASIAN	MALE	43.3189	2.50798	19
		FEMALE	40.0202	2.38212	41
		Total	41.0648	2.85668	60
	HISPANIC	MALE	42.9300	3.84929	5
		FEMALE	40.2162	2.39612	8
		Total	41.2600	3.19006	13
	Total	MALE	43.2379*	2.74326	24
		FEMALE	40.0522	2.36038	49
		Total	41.0996	2.89636	73
Total	CAUCASIAN	MALE	42.1515	2.97250	39
		FEMALE	39.8007	2.87913	99
		Total	40.4651	3.08367	138
	HISPANIC	MALE	41.4761	4.50523	23
		FEMALE	39.9249	2.67173	41
		Total	40.4823	3.49039	64
	Total	MALE	41.9010	3.59621	62
		FEMALE	39.8371	2.81099	140
		Total	40.4705	3.20933	202

Class II Maximum Ramus Breadth (mm) (L)

Descriptive Statistics
Dependent Variable: Maximum Ramus Breadth (L) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	39.3000	.	1
		Asian	44.4000	.	1
		Total	41.8500	3.60624	2
	FEMALE	Caucasian	39.9143	5.20610	7
		Hispanic	39.2425	1.95019	4
		Black	36.3000	.	1
		Asian	37.9000	.	1
		Total	39.2746	3.95429	13
	Total	Caucasian	39.9143	5.20610	7
		Hispanic	39.2540	1.68911	5
		Black	36.3000	.	1
		Asian	41.1500	4.59619	2
		Total	39.6180	3.89265	15
Normodivergent	MALE	Hispanic	40.6833	2.57989	3
		Black	47.8000	.	1
		Asian	37.7000	.	1
		Total	41.5100	4.16659	5
	FEMALE	Caucasian	39.9775	4.35898	4
		Hispanic	37.3167	3.21366	6
		Black	43.0000	.56569	2
		Total	39.1508	3.83182	12
	Total	Caucasian	39.9775	4.35898	4
		Hispanic	38.4389	3.30943	9
		Black	44.6000	2.80000	3
		Asian	37.7000	.	1
		Total	39.8447	3.95756	17
Hypodivergent	MALE	Caucasian	46.8000	.	1
		Hispanic	43.5500	3.32340	2
		Asian	42.9000	.	1
		Total	44.2000	2.60384	4
	FEMALE	Caucasian	39.3840	3.28805	5
		Hispanic	43.1000	.	1
		Black	44.8200	.	1
		Asian	37.8000	.	1
		Total	40.3300	3.42165	8
	Total	Caucasian	40.6200	4.22081	6
		Hispanic	43.4000	2.36432	3
		Black	44.8200	.	1
		Asian	40.3500	3.60624	2
		Total	41.6200	3.59586	12
Total	MALE	Caucasian	46.8000	.	1
		Hispanic	41.4083	2.81255	6
		Black	47.8000	.	1
		Asian	41.6667	3.51615	3

		Total	42.5500	3.46504	11
	FEMALE	Caucasian	39.7644	4.19468	16
		Hispanic	38.5427	3.07887	11
		Black	41.7800	3.76691	4
		Asian	37.8500	.07071	2
		Total	39.4855	3.70274	33
	Total	Caucasian	40.1782	4.40538	17
		Hispanic	39.5541	3.22323	17
		Black	42.9840	4.22969	5
		Asian	40.1400	3.24854	5
		Total	40.2516	3.84669	44

Class III Maximum Ramus Breadth (mm) (L)

Dependent Variable: Maximum Ramus Breadth (L) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	38.1000	5.65685	2
		Asian	43.4000	.98995	2
		Total	40.7500	4.51184	4
	FEMALE	Caucasian	38.5950	4.67398	2
		Hispanic	30.7000	.	1
		Black	39.4000	.	1
		Total	36.8225	4.90775	4
	Total	Caucasian	38.3475	4.24622	4
		Hispanic	30.7000	.	1
		Black	39.4000	.	1
		Asian	43.4000	.98995	2
		Total	38.7862	4.84294	8
Normodivergent	MALE	Caucasian	43.1080	4.00653	5
		Hispanic	43.5200	3.86355	5
		Black	40.9700	.	1
		Asian	46.9500	2.33345	2
		Middle Eastern/India	41.8000	.	1
		Total	43.5579*	3.54294	14
	FEMALE	Caucasian	39.2725	2.23831	8
		Middle Eastern/India	42.2000	.	1
		Total	39.5978	2.30999	9
	Total	Caucasian	40.7477	3.47064	13
		Hispanic	43.5200	3.86355	5
		Black	40.9700	.	1
		Asian	46.9500	2.33345	2
		Middle Eastern/India	42.0000	.28284	2
		Total	42.0083	3.64181	23
Hypodivergent	MALE	Caucasian	43.3300	3.99395	4
		Hispanic	42.2400	1.29345	5
		Black	42.1500	3.04056	2
		Total	42.6200	2.58789	11
	FEMALE	Caucasian	41.1871	2.82191	7
		Hispanic	40.4367	3.38468	3
		Total	40.9620	2.82595	10
	Total	Caucasian	41.9664	3.27600	11
		Hispanic	41.5638	2.25837	8
		Black	42.1500	3.04056	2
		Total	41.8305	2.76808	21
Total	MALE	Caucasian	42.2782	4.32258	11
		Hispanic	42.8800	2.79873	10
		Black	41.7567	2.25536	3
		Asian	45.1750	2.51843	4
		Middle Eastern/India	41.8000	.	1
		Total	42.8148	3.36168	29
	FEMALE	Caucasian	39.9812	2.76966	17

		Hispanic	38.0025	5.59804	4
		Black	39.4000	.	1
		Middle Eastern/India	42.2000	.	1
		Total	39.7083	3.27497	23
	Total	Caucasian	40.8836	3.57367	28
		Hispanic	41.4864	4.22885	14
		Black	41.1675	2.18622	4
		Asian	45.1750	2.51843	4
		Middle Eastern/India	42.0000	.28284	2
		Total	41.4408	3.64119	52

Class I Minimum Ramus Breadth (mm) (R)

Dependent Variable: Minimum Ramus Breadth (R) (mm)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	29.4783	3.35097	6
		FEMALE	28.6679	2.35241	14
		Total	28.9110	2.62421	20
	HISPANIC	MALE	31.3120	1.52043	5
		FEMALE	29.0433	2.42610	9
		Total	29.8536	2.36770	14
	Total	MALE	30.3118*	2.73060	11
		FEMALE	28.8148	2.33355	23
		Total	29.2991	2.52885	34
Normodivergent	CAUCASIAN	MALE	30.9314	3.35637	14
		FEMALE	30.0895	2.17316	44
		Total	30.2928	2.50280	58
	HISPANIC	MALE	31.3215	1.96668	13
		FEMALE	30.6475	2.01467	24
		Total	30.8843	1.99722	37
	Total	MALE	31.1193*	2.73079	27
		FEMALE	30.2865	2.12048	68
		Total	30.5232	2.32597	95
Hypodivergent	CAUCASIAN	MALE	32.7289	2.29042	19
		FEMALE	29.8059	1.99494	41
		Total	30.7315	2.48574	60
	HISPANIC	MALE	32.3180	2.79984	5
		FEMALE	31.9938	1.73242	8
		Total	32.1185	2.09541	13
	Total	MALE	32.6433*	2.34478	24
		FEMALE	30.1631	2.10279	49
		Total	30.9785*	2.46587	73
Total	CAUCASIAN	MALE	31.5836	3.05430	39
		FEMALE	29.7710	2.15652	99
		Total	30.2833	2.56616	138
	HISPANIC	MALE	31.5361	2.03296	23
		FEMALE	30.5580	2.22925	41
		Total	30.9095	2.19596	64
	Total	MALE	31.5660	2.70231	62
		FEMALE	30.0015	2.19957	140
		Total	30.4817	2.46681	202

Class II Minimum Ramus Breadth (mm) (R)

Descriptive Statistics
Dependent Variable: Minimum Ramus Breadth (R) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	30.1000	.	1
		Asian	34.7000	.	1
		Total	32.4000	3.25269	2
	FEMALE	Caucasian	28.3757	3.82872	7
		Hispanic	29.7125	1.16789	4
		Black	27.8000	.	1
		Asian	27.7000	.	1
		Total	28.6908	2.86781	13
	Total	Caucasian	28.3757	3.82872	7
		Hispanic	29.7900	1.02616	5
		Black	27.8000	.	1
		Asian	31.2000	4.94975	2
		Total	29.1853	3.08359	15
Normodivergent	MALE	Hispanic	32.5033	3.33617	3
		Black	33.7000	.	1
		Asian	25.5000	.	1
		Total	31.3420	4.06187	5
	FEMALE	Caucasian	29.9825	1.95224	4
		Hispanic	29.9467	1.94025	6
		Black	35.8500	1.90919	2
		Total	30.9425	2.88736	12
	Total	Caucasian	29.9825	1.95224	4
		Hispanic	30.7989	2.60183	9
		Black	35.1333	1.83394	3
		Asian	25.5000	.	1
		Total	31.0600	3.14507	17
Hypodivergent	MALE	Caucasian	36.2000	.	1
		Hispanic	31.6000	.84853	2
		Asian	32.0000	.	1
		Total	32.8500	2.29420	4
	FEMALE	Caucasian	29.5680	3.09324	5
		Hispanic	32.3000	.	1
		Black	33.3400	.	1
		Asian	29.4000	.	1
		Total	30.3600	2.80241	8
	Total	Caucasian	30.6733	3.87105	6
		Hispanic	31.8333	.72342	3
		Black	33.3400	.	1
		Asian	30.7000	1.83848	2
		Total	31.1900	2.81712	12
Total	MALE	Caucasian	36.2000	.	1
		Hispanic	31.8017	2.34240	6
		Black	33.7000	.	1
		Asian	30.7333	4.72899	3

		Total	32.0827	3.12514	11
	FEMALE	Caucasian	29.1500	3.11451	16
		Hispanic	30.0755	1.68789	11
		Black	33.2100	3.95260	4
		Asian	28.5500	1.20208	2
		Total	29.9142	2.95333	33
	Total	Caucasian	29.5647	3.46664	17
		Hispanic	30.6847	2.05385	17
		Black	33.3080	3.43006	5
		Asian	29.8600	3.60181	5
		Total	30.4564	3.10876	44

Class III Minimum Ramus Breadth (mm) (R)

Dependent Variable: Minimum Ramus Breadth (R) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	28.7500	4.17193	2
		Asian	30.7000	1.13137	2
		Total	29.7250	2.73785	4
	FEMALE	Caucasian	26.6850	2.38295	2
		Hispanic	24.2000	.	1
		Black	31.7000	.	1
		Total	27.3175	3.43529	4
	Total	Caucasian	27.7175	3.01925	4
		Hispanic	24.2000	.	1
		Black	31.7000	.	1
		Asian	30.7000	1.13137	2
		Total	28.5213	3.15058	8
Normodivergent	MALE	Caucasian	30.6480	2.86557	5
		Hispanic	35.0200	2.58399	5
		Black	35.2800	.	1
		Asian	34.2000	2.68701	2
		Middle Eastern/India	39.7000	.	1
		Total	33.6943*	3.51979	14
	FEMALE	Caucasian	28.4450	2.76626	8
		Middle Eastern/India	30.3000	.	1
		Total	28.6511	2.66045	9
	Total	Caucasian	29.2923	2.90609	13
		Hispanic	35.0200	2.58399	5
		Black	35.2800	.	1
		Asian	34.2000	2.68701	2
		Middle Eastern/India	35.0000	6.64680	2
		Total	31.7209	4.02837	23
Hypodivergent	MALE	Caucasian	31.9950	4.90864	4
		Hispanic	32.0400	3.03035	5
		Black	34.7000	2.96985	2
		Total	32.5073	3.59991	11
	FEMALE	Caucasian	30.7257	3.34925	7
		Hispanic	32.5167	2.22280	3
		Total	31.2630	3.05364	10
	Total	Caucasian	31.1873	3.79065	11
		Hispanic	32.2188	2.59229	8
		Black	34.7000	2.96985	2
		Total	31.9148	3.32886	21
Total	MALE	Caucasian	30.7927	3.69821	11
		Hispanic	33.5300	3.08475	10
		Black	34.8933	2.12653	3
		Asian	32.4500	2.62996	4
		Middle Eastern/India	39.7000	.	1
		Total	32.6966	3.59954	29
	FEMALE	Caucasian	29.1771	3.16272	17

		Hispanic	30.4375	4.53714	4
		Black	31.7000	.	1
		Middle Eastern/India	30.3000	.	1
		Total	29.5548	3.25088	23
	Total	Caucasian	29.8118	3.41156	28
		Hispanic	32.6464	3.66608	14
		Black	34.0950	2.35883	4
		Asian	32.4500	2.62996	4
		Middle Eastern/India	35.0000	6.64680	2
		Total	31.3069	3.76230	52

Class I Minimum Ramus Breadth (mm) (L)

Dependent Variable: Minimum Ramus Breadth (L) (mm)

Group Vertical Classification	Race	Sex	Mean	Std. Deviation	N
Hyperdivergent	CAUCASIAN	MALE	29.6533	2.82922	6
		FEMALE	28.2114	2.31714	14
		Total	28.6440	2.49793	20
	HISPANIC	MALE	31.6740	2.83159	5
		FEMALE	29.4833	2.19523	9
		Total	30.2657	2.57277	14
	Total	MALE	30.5718*	2.88495	11
		FEMALE	28.7091	2.30822	23
		Total	29.3118	2.61847	34
Normodivergent	CAUCASIAN	MALE	31.3721	3.16946	14
		FEMALE	29.9468	2.46000	44
		Total	30.2909	2.68977	58
	HISPANIC	MALE	31.6246	3.05687	13
		FEMALE	30.7887	2.47593	24
		Total	31.0824	2.68235	37
	Total	MALE	31.4937*	3.05812	27
		FEMALE	30.2440	2.48044	68
		Total	30.5992	2.70059	95
Hypodivergent	CAUCASIAN	MALE	33.5353	2.33608	19
		FEMALE	30.0056	2.16564	41
		Total	31.1233	2.75430	60
	HISPANIC	MALE	31.7200	2.88565	5
		FEMALE	31.6263	1.52314	8
		Total	31.6623	2.03254	13
	Total	MALE	33.1571*	2.50723	24
		FEMALE	30.2702	2.14777	49
		Total	31.2193*	2.63592	73
Total	CAUCASIAN	MALE	32.1615	3.03996	39
		FEMALE	29.7258	2.37994	99
		Total	30.4141	2.79761	138
	HISPANIC	MALE	31.6561	2.84084	23
		FEMALE	30.6656	2.32440	41
		Total	31.0216	2.54520	64
	Total	MALE	31.9740	2.95434	62
		FEMALE	30.0010	2.39425	140
		Total	30.6066	2.72860	202

Class II Minimum Ramus Breadth (mm) (L)

Descriptive Statistics
Dependent Variable: Minimum Ramus Breadth (L) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Hispanic	29.8000	.	1
		Asian	33.8000	.	1
		Total	31.8000	2.82843	2
	FEMALE	Caucasian	28.1457	4.01257	7
		Hispanic	29.7375	1.75089	4
		Black	27.7000	.	1
		Asian	29.8000	.	1
		Total	28.7285	3.08838	13
	Total	Caucasian	28.1457	4.01257	7
		Hispanic	29.7500	1.51658	5
		Black	27.7000	.	1
		Asian	31.8000	2.82843	2
		Total	29.1380	3.14881	15
Normodivergent	MALE	Hispanic	31.5533	2.24110	3
		Black	36.6000	.	1
		Asian	26.6000	.	1
		Total	31.5720	3.87452	5
	FEMALE	Caucasian	29.5950	1.34019	4
		Hispanic	29.7800	2.79385	6
		Black	36.1000	.70711	2
		Total	30.7717	3.20705	12
	Total	Caucasian	29.5950	1.34019	4
		Hispanic	30.3711	2.63065	9
		Black	36.2667	.57735	3
		Asian	26.6000	.	1
		Total	31.0071	3.31140	17
Hypodivergent	MALE	Caucasian	35.6000	.	1
		Hispanic	32.8500	.77782	2
		Asian	31.5000	.	1
		Total	33.2000*	1.77951	4
	FEMALE	Caucasian	28.5000	1.90000	5
		Hispanic	32.7000	.	1
		Black	33.9500	.	1
		Asian	29.4000	.	1
		Total	29.8188	2.63709	8
	Total	Caucasian	29.6833	3.36001	6
		Hispanic	32.8000	.55678	3
		Black	33.9500	.	1
		Asian	30.4500	1.48492	2
		Total	30.9458	2.83913	12
Total	MALE	Caucasian	35.6000	.	1
		Hispanic	31.6933	1.84225	6
		Black	36.6000	.	1
		Asian	30.6333	3.67741	3

		Total	32.2055	2.89550	11
	FEMALE	Caucasian	28.6187	2.85052	16
		Hispanic	30.0300	2.36793	11
		Black	33.4625	3.99403	4
		Asian	29.6000	.28284	2
		Total	29.7358	3.07407	33
	Total	Caucasian	29.0294	3.23798	17
		Hispanic	30.6171	2.28831	17
		Black	34.0900	3.73269	5
		Asian	30.2200	2.66496	5
		Total	30.3532	3.18629	44

Class III Minimum Ramus Breadth (mm) (L)

Dependent Variable: Minimum Ramus Breadth (L) (mm)

Group Vertical Classification	Sex	Race	Mean	Std. Deviation	N
Hyperdivergent	MALE	Caucasian	29.7000	2.26274	2
		Asian	30.2500	.91924	2
		Total	29.9750	1.44539	4
	FEMALE	Caucasian	26.7900	.41012	2
		Hispanic	23.3000	.	1
		Black	31.9000	.	1
		Total	27.1950	3.54985	4
	Total	Caucasian	28.2450	2.14136	4
		Hispanic	23.3000	.	1
		Black	31.9000	.	1
		Asian	30.2500	.91924	2
		Total	28.5850*	2.91618	8
Normodivergent	MALE	Caucasian	30.8180	2.68935	5
		Hispanic	33.4400	2.78173	5
		Black	34.2100	.	1
		Asian	34.1500	5.30330	2
		Middle Eastern/India	34.8000	.	1
		Total	32.7571*	3.02940	14
	FEMALE	Caucasian	28.7575	2.92001	8
		Middle Eastern/India	29.9000	.	1
		Total	28.8844	2.75784	9
	Total	Caucasian	29.5500	2.91089	13
		Hispanic	33.4400	2.78173	5
		Black	34.2100	.	1
		Asian	34.1500	5.30330	2
		Middle Eastern/India	32.3500	3.46482	2
		Total	31.2417	3.45301	23
Hypodivergent	MALE	Caucasian	32.4100	4.22237	4
		Hispanic	32.1200	3.30484	5
		Black	36.8500	2.47487	2
		Total	33.0855	3.71655	11
	FEMALE	Caucasian	30.9871	3.17924	7
		Hispanic	32.8067	3.44124	3
		Total	31.5330	3.18472	10
	Total	Caucasian	31.5045	3.45375	11
		Hispanic	32.3775	3.12264	8
		Black	36.8500	2.47487	2
		Total	32.3462	3.47875	21
Total	MALE	Caucasian	31.1936	3.14040	11
		Hispanic	32.7800	2.96266	10
		Black	35.9700	2.32071	3
		Asian	32.2000	3.83753	4
		Middle Eastern/India	34.8000	.	1
		Total	32.4979	3.23981	29
	FEMALE	Caucasian	29.4441	3.11273	17

		Hispanic	30.4300	5.52168	4
		Black	31.9000	.	1
		Middle Eastern/India	29.9000	.	1
		Total	29.7422	3.40171	23
	Total	Caucasian	30.1314	3.18613	28
		Hispanic	32.1086	3.78500	14
		Black	34.9525	2.78059	4
		Asian	32.2000	3.83753	4
		Middle Eastern/India	32.3500	3.46482	2
		Total	31.2790	3.55871	52

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